

# DISTANT SUNS™



User Manual



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I wish to thank my keen eyed beta testers for their hard work and long hours:

Robin La Pasha, Fred Klein and David Brodbeck.



## INTRODUCTION

The night sky has fascinated mankind for millennia. How many times have you caught yourself gazing upward, wondering which bright "star" that was, setting just after sunset, or what constellation was rising over the neighbor's trees? Let DISTANT SUNS show you.

Using a database of over 2200 stars (expandable to 9100 or more) DISTANT SUNS is a powerful tool for acquainting you with the heavens. It will provide you with a more accurate representation of the sky than previously found on personal computers (at least, I like to think so). Indeed, its power rivals that of a small planetarium where, unhindered by your location on the planet, time of day, or the weather, you can freely explore different parts of the sky.

DISTANT SUNS was written to take full advantage of the Amiga's color, graphic interface and processor speed. Simply by pointing and clicking with the mouse, DISTANT SUNS lets you discover a fascinating variety of celestial phenomena - and in the process learn the fundamentals of astronomy.

### The Universe in "Brief"

In the book Hitchhiker's Guide to the Galaxy, author Douglas Adams sums up the Universe this way:

"Space is big. Really big. You just won't believe how vastly hugely mind-bogglingly big it is. I mean, you may think it's a long way down the road to the [pharmacy], but that's just peanuts to space."

And so it is. Consider a light beam travelling at 186,000 miles a second leaving the surface of the sun when your morning alarm-clock rings. It is 6:00 am, Monday, February 8, 1988. By the time you've finally just started to consider rolling out of the sack at 6:08, the beam is sweeping through the orbit of the earth



as it heads outward bound towards the edge of the solar-system. After you're done showering, and ready to sit down to a bowl of Rice Krispies, it's 6:41, and Jupiter will be catching sight of the ray. It'll be midmorning, 11:12, when the beam sweeps past the orbit of Pluto (and you thought that you had a busy morning!) It won't be until the following Saturday afternoon, 5 1/2 days later, when the beam finally reaches the hypothesized cloud of comets, the "Oort Cloud," said to surround the solar system. At this point the beam leaves the solar system, but is only just beginning its long journey beyond infinity.

Now you won't have to bother thinking about the ray until the next Presidential election in the fall of 1992. However after all this waiting, the beam has only reached the nearest star next to the sun, Proxima Centuri. In 1994 it reaches Barnard's Star, followed by tiny Wolf 359 just in time for the 1996 Olympics. As you celebrate the turn of the century the beam will be racing by Tau Ceti with a full 20 stars behind it. In the next year it will overcome BD5-1668, L725-32, Kapteyn's Star and Kruger 60A. The sun itself would appear as a rather bland yellowish star slowly receding into the galactic darkness.

By the end of the next century, your great-great-grandchildren will be alive as the beam passes beyond the likes of Sharatan, Hamal, Algol, and Aldebaran. Likewise it will have overtaken Regulus, Talitha, Miaplacidus, and Arcturus.

In 2219, the sun's light would just be reaching the open cluster The Pleiades, in the constellation of Taurus. The Starship Enterprise is just beginning it's 5 year journey into television history. Even after all of this, our journey is still beginning.

Now in your imagination, leave this age behind. Leave everything you've ever done, or known, behind. Leave your CD collection behind. Were the beam directed towards the constellation of Sagittarius it would be headed to the center of our galaxy the Milky Way. However it won't reach this point



until about the year 32,000 AD. Yet there is still another 50,000 years before the ray can exit the other side of the galaxy. When it does, it will be leaving over 100 billion stars behind. Yet this galaxy is an unremarkable one of unremarkable size with many, many others beyond. And the journey is *still* beginning.

By 200,000 AD the beam will be passing by the Magellanic Clouds in Tucana, satellite galaxies to our own. After this is nothing, nothing for the next 1.8 *million* years. Back on earth, we would see the sun as somewhat larger, turning a reddish hue as it slowly burns out. But now, looming ahead is the Andromeda galaxy, our "sister" galaxy and a member of the local group. Looking back towards the Milky Way, you would see a view similar to what the Andromeda galaxy looks like on a fall evening: A fuzzy elliptical patch (although the sight would probably be more impressive). Another couple of million years will finally see this beam escaping our corner of the universe, travelling out to the open regions of space. Adams said it was big.

Now advance again, not another few million years, but a full 20 billion years from the present. The light beam from the sun has at last reached the edge of the known universe. If the solar system still exists it'll likely be a rather cold and uninviting place, the sun having burned itself out 15 billion years previously. Out here, what the beam would encounter is a giant unknown. Long ago however, scientists were able to see some objects they said were out here, quasars. But these also remain a mystery as do so many other things.

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One of the amazing things in the universe is the range of both times and distances. For instance, in the above example we dealt with distances measured in trillions times trillions of miles. Yet, at the same time, some of the most interesting objects such as black holes or neutron stars may measure only



5 to 10 miles in diameter. Or we commonly measure stellar processes in terms of millions of years. Yet there are stars, "pulsars," which flash 30 times a second!

As you can see, the universe has no shortage of variety. It is my hope that DISTANT SUNS will serve to introduce you to this variety, and perhaps encourage you to explore further on your own.



## GETTING STARTED

DISTANT SUNS will run on a 512K machine, but barely. If you don't have expanded memory, make sure that no other tasks are running, no Marble Madness, no Bard's Tale, nothing (sorry). This will both give DISTANT SUNS the memory it needs, and permit it to shut down the Workbench screen saving an additional 30K\*.

If you do have extended memory then there should be no problems whatsoever running additional programs. Just make sure that there is at least 380K free. Using the extended data disk will take about another 150K or more. On top of this, I would also recommend using FACC by ASDG when using the point-and-identify option.

DISTANT SUNS is started in the traditional fashion by clicking on the icon. When loaded, you will be presented with a quiz question, and the location of the answer in this manual by paragraph and word (paragraph #1 is the first full paragraph, while paragraph #0 is one split from the previous page). Type in the answer to the question, and press the RETURN key. A correct answer activates the main program. An incorrect response causes the program to prompt you again for the answer. Three incorrect responses and the program returns you to Workbench.

You will be presented the entire northern hemisphere of the sky centered on the North Star, Polaris. DISTANT SUNS is now set to a field-of-view of 180 degrees, with "Planetarium" mode activated. Besides the stars, you'll see the planets as colored points. The sun is the yellow disk, and the moon is the white disk. Over on the right is the control panel which presents status and position information. The menus operate in the usual fashion. When positioned over the stars, the left mouse button may be used to center any point of the sky by simply clicking on that point.



In order to see the sky in its full splendor, DISTANT SUNS should be used in a darkened room. Also, some adjustment of your monitor may be necessary to get the full range of stellar brightnesses. When the lights are out, you will probably notice that faint scan-lines are visible in the "black" background. Vary both the brightness and the contrast controls on your monitor so that the scan-lines just vanish. This should place the dimmest stars just slightly above the threshold of visibility as they would normally be.

Now *our* journey is just beginning.

\* You should boot from the DISTANT SUNS disk, and remove any disk from the external drive. If for any reason you should still have any problems, you should try unplugging your external floppy drive (making sure the power is off first).



## BASIC CONCEPTS

It is at this point that we ought to take a brief moment to explore some of the basic concepts of observational astronomy, which will help you in working with DISTANT SUNS.

For starters, it is helpful to think of the sky in the same way the early astronomers did — by imagining the stars and planets as being attached to the inside of a hollow sphere with the earth at the center. This sphere, in turn, revolves around the earth, creating the stellar motions.

Variations on this theme had each planet on a separate crystal-line sphere revolving on its own, which explained their independent movements. But for now, the single sphere model will do.

Another concept which is essential for understanding how astronomers describe the various locations of celestial objects is that of coordinate systems.

We are all familiar, in one way or another, with coordinate systems. This is a method of specifying the location of a particular place, be it on a piece of paper or the earth. Our home addresses, for example, represent one coordinate system, the earth's latitude and longitude lines are another.

In order to pinpoint the location of a star, astronomers have

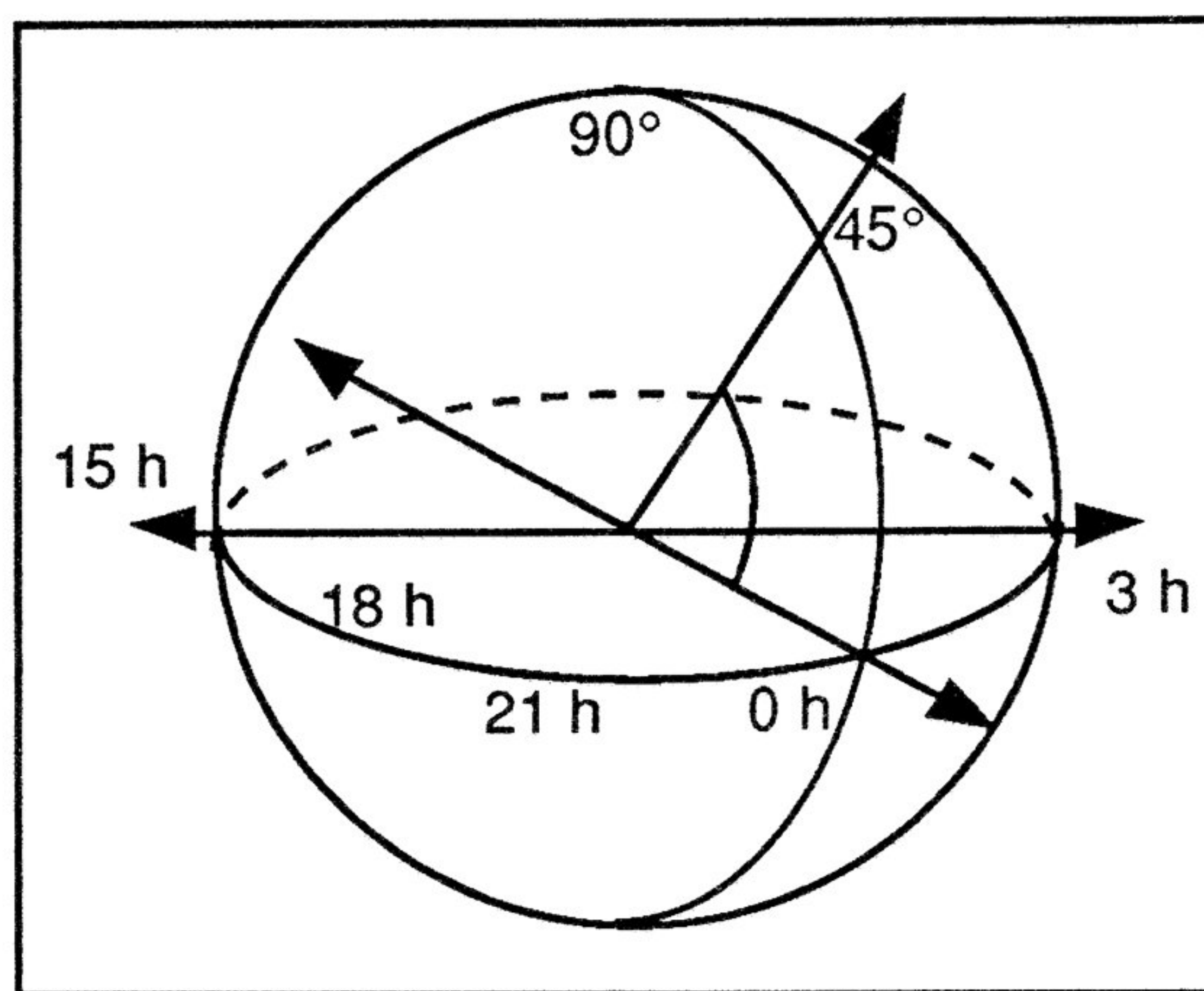
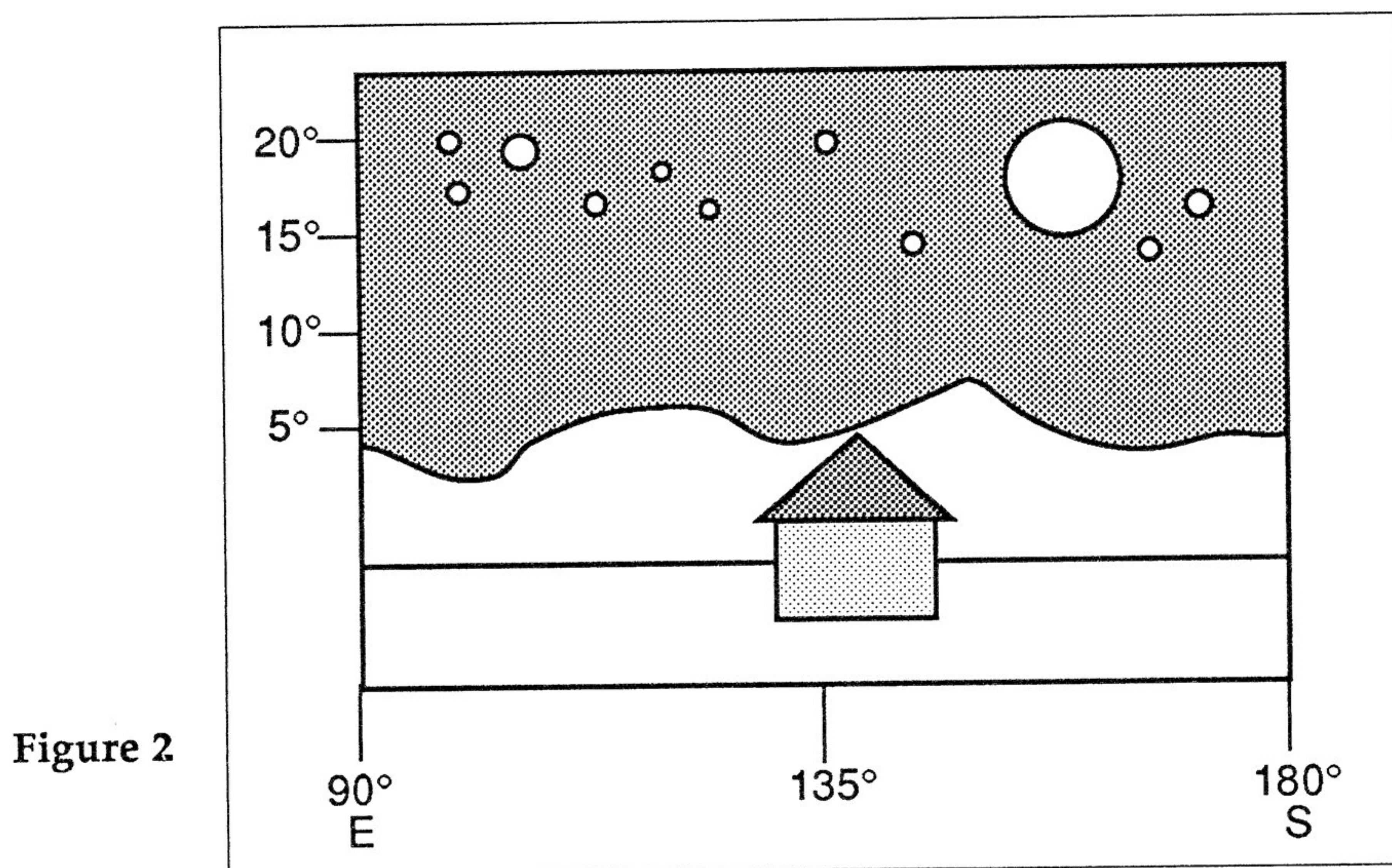


Figure 1



developed their own system for the sky, analogous to the earth's, (fig. 1). The sky's latitude is termed declination, (or "dec") and its longitude, right ascension, (or "RA").

In this "equatorial coordinate system," declination is measured in degrees, as is latitude, and like latitude, ranges from -90 degrees to +90 degrees. Zero degrees declination is called the "celestial equator."



Right ascension, on the other hand, is measured not in degrees, but in hours, minutes and seconds, with each hour being the equivalent of 15 degrees.

A second coordinate system that is important is the horizon system, used in specifying the location of an object in your own sky. The two coordinates used are "azimuth", or compass heading, and "altitude", or the angular elevation above the horizon (fig. 2). Both are measured in degrees. And while right ascension increases by motion towards the left, azimuth increases to the right. Because of the earth's rotation, horizon



coordinates of a particular object are constantly changing, while its equatorial coordinates are constant. DISTANT SUNS defaults to using the equatorial coordinate system called "Planetarium Mode," as opposed to your local coordinate system. This was done for two reasons:

- \* Planetarium mode is much faster which makes navigating around the sky all the easier.

- \* Planetarium mode removes the ambiguities introduced by using your local system. That is, Altair's equatorial coordinates are always going to be the same, but its local horizon position changes constantly minute-by-minute.



## CONTROL PANEL AND MOUSE

On the right side of the screen is the **control panel** (fig. 3). This permits you to scroll around through the sky as well as displaying basic status information.

At the top of the control panel you'll find four directional arrows (Fig. 3a) that let you select the scrolling motion of your screen display. Think of these arrows as simply navigational instruments that point you in the direction you wish to move.

Move the sky by clicking the left mouse button on any of the arrows. All movement is stopped by clicking a second time on top of the active arrow. The left and right arrows control right ascension (or azimuth when in local mode), and the up/down arrows control the declination (or altitude). Each step is 5 degrees in either direction ("20 minutes" in RA) or 1 degree when the field-of-view is 20 degrees or less.

If you look at the extreme northern or southern parts of the sky, where the declination is close to  $\pm 90$  degrees, and scroll either right or left, stars will be seen to rotate around some central point. This is caused by the fact that our hollow sphere model rotates on an axis going through the northern and southern points. What you have done, in effect, is

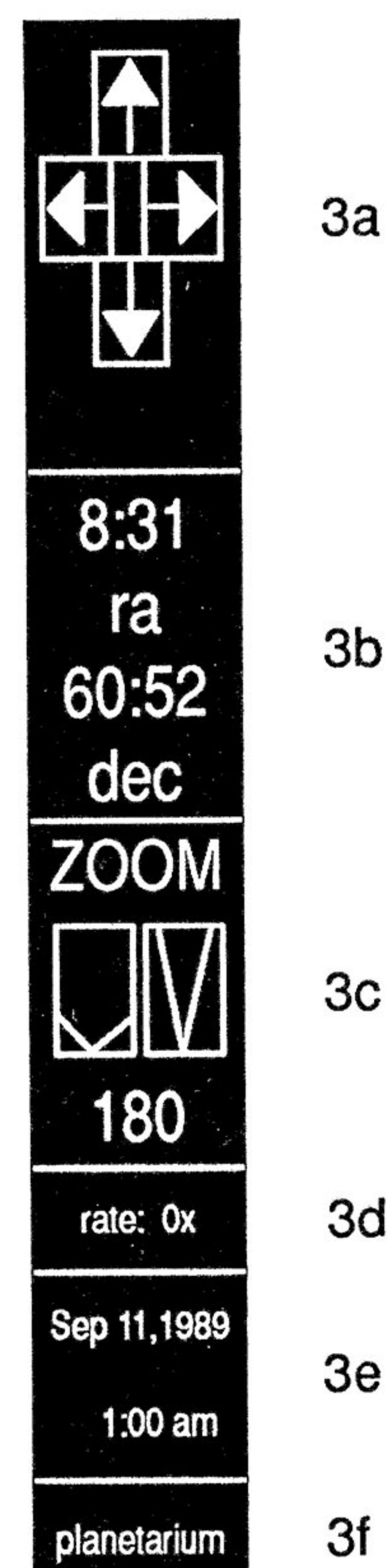
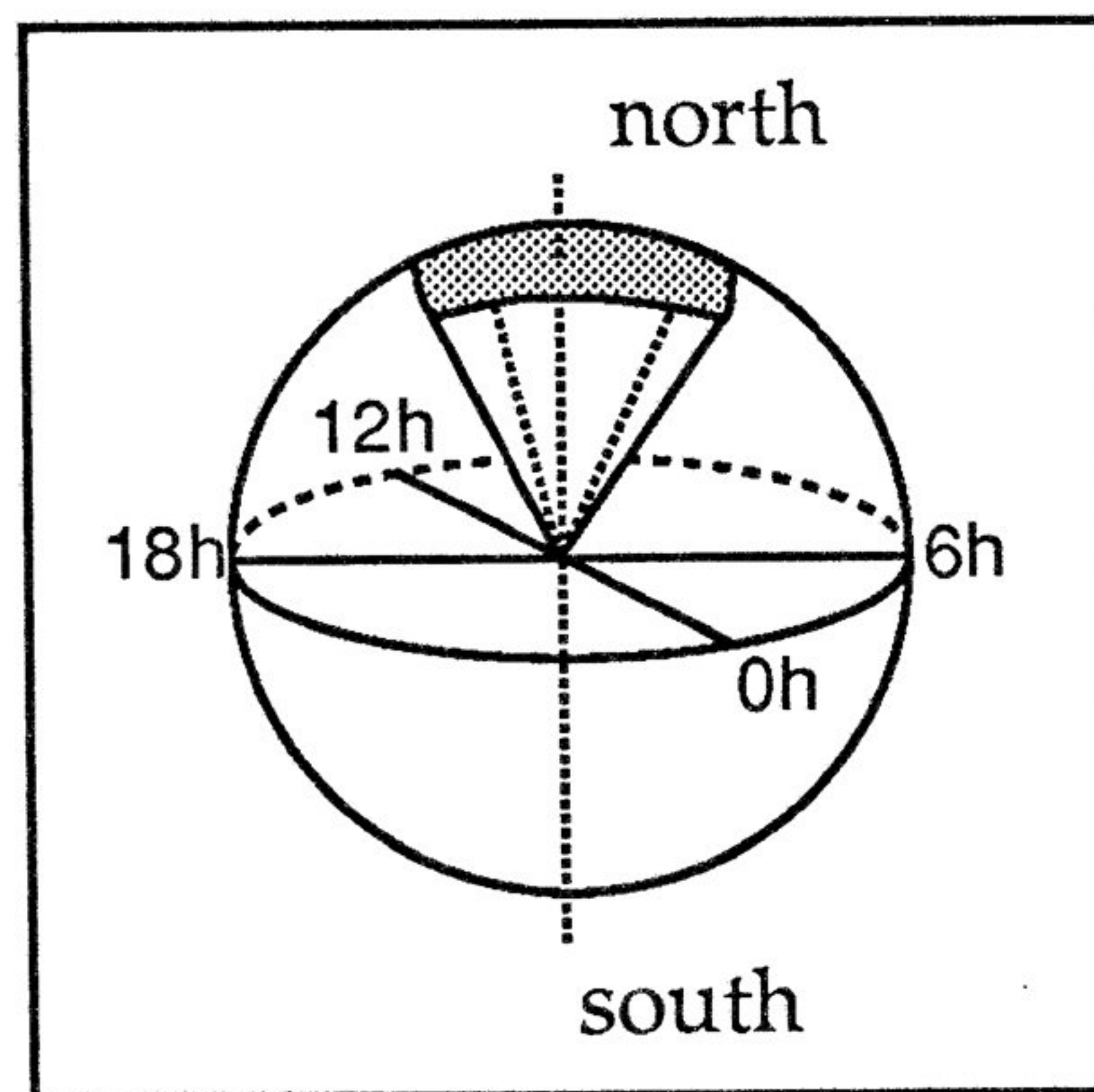


Figure 3



to lean back and look up. And what you are seeing are the stars moving around the axis (fig. 4). The point in the northern sky is marked by the "North Star," Polaris.

Figure 4



## Coordinates Window

Beneath the directional arrows is the coordinates window, (fig. 3b), pinpointing the location of the screen's center. This point may be highlighted by turning on the crosshairs under the Extras menu. If you are in Planetarium mode, the control panel shows you the coordinates in right ascension, measured in hours and minutes, and declination, measured in degrees. For example, at startup the screen is centered on the North Pole with coordinates of 0 hours RA and 90 degrees Declination. In Local mode, the coordinates will be in altitude and azimuth.

## Zoom Buttons

The next items on the panel are the zoom controls (fig. 3c), letting you control the field-of-view ("FOV") as if you had a giant zoom lens. They determine how much of the sky is visible at any one time. With these, you can zoom in for a closer view, or out to see more stars at once. Be aware that the sky refresh slows as the number of objects on the screen increases due to widening the FOV. For large zooms, you may want to use the "FOV" menu item in the Displays menu.



Measured in degrees width, a 90 degree FOV means that 45 degrees of the sky is visible on either side of the screen's center (fig. 5). The smaller the field, the larger the images. The smallest FOV is 15 and the largest is 180 which will show you one-half of the entire sky. The most comfortable region is between 40 and 50 degrees.

Because DISTANT SUNS is trying to display a 3-dimensional "curved" surface on a flat, 2-dimensional screen, certain distortions will creep in. These are similar to what a wide-angle camera lens might generate. The distortions are most noticeable along the edge of the display while using an FOV greater than 70 or 80 degrees. Their least distortion will be in the center of the screen.

### Other Stuff

Below the zoom controls is the rate display (fig. 3d). This tells you what speed DISTANT SUNS' internal clock is running when compared to the real world. Next is the date and time (fig. 3e).

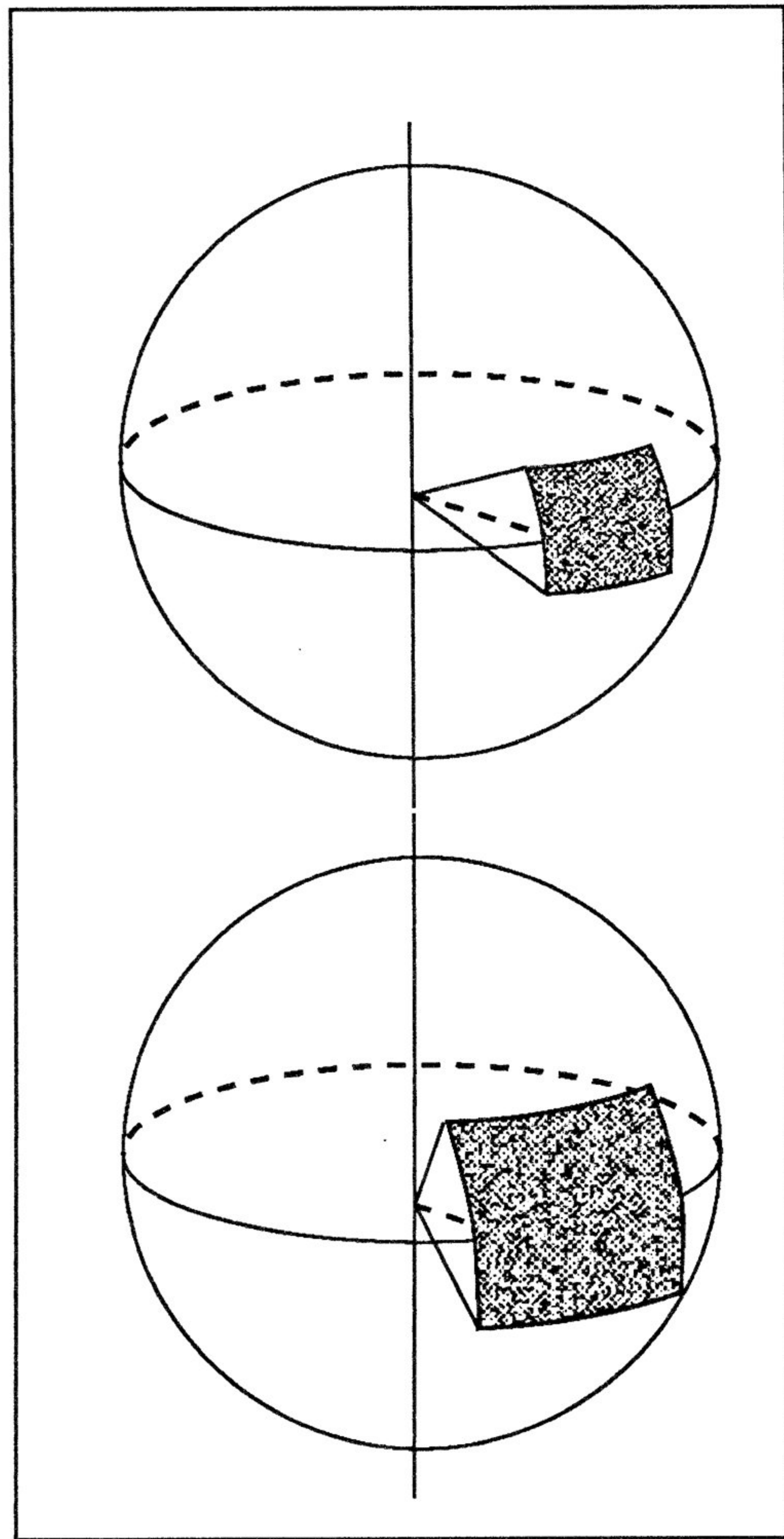


Figure 5



The date will be red when the years are AD, and yellow when BC.

The last item in the panel is the mode window (fig. 3f). This will remind you whether you're in local, flashcard or planetarium modes. These are selected from the Modes menu item in the Displays menu.



## MENU CHOICES

Now that you've had a chance to checkout DISTANT SUNS' control panel, let's look at the menu choices available to you. The following sections will summarize the options. Additional details will be given in later chapters. (Notice that a number of the menu items have keyboard equivalents, and that some options are mutually exclusive with others. Selecting these will automatically lock out others).

### Systems Menu

#### Control Panel

This will let you open or close the control-panel on the right side of the screen.

#### Free memory

Selecting this will bring up dynamic memory monitor. You may want to check this periodically when using a 512K machine.

#### Quickview

Quickview will rapidly set up the display in Local mode, oriented toward any one of nine directions. The horizon line, and constellation and planetary names will also be switched on. This saves you the time it would otherwise take to turn on everything separately and wait through several screen refreshes.

The horizon line indicates where your own horizon is, marking every 5 degrees. The local-altitude option under the "Markers" menu will draw a scale up the center of the screen indicating the altitude in degrees above the horizon.



The “up” option will display the entire sky as seen from your location. Remember that because of the wide FOV, the constellations near the edges will be “scrunched up.” The display is drawn as if you were outdoors, oriented North, looking up. That way, North would be “below” your chin, or down relative to your face.

No Exit is required from Quickview—just select your options as you normally would.

## **Redraw**

With the many options that Distant Suns offers it is possible that from time to time various screen elements may trash others. Redraw will simply refresh the entire screen to clean it up if possible.

## **Reset**

From time to time you may want to turn off all of the objects and identifiers previously loaded onto the screen. Reset will turn off all selected items at once, returning the sky to a plain unadorned state.

## **Settings**

These options will allow you to set your date, time, location and time-rate.

At startup, DISTANT SUNS will read the current date and time from your computer’s internal clock. If you haven’t set it, you’ll need to put in these values yourself.

Selecting “environment” will open up a large window showing the current time, location, etc. needed by DISTANT SUNS at startup. You may change any of the values at will by simply clicking on them with either of the mouse buttons. The left button will increase the displayed value, the right will decrease



it. A single click of the buttons will change the value by one step, whereas holding down on the button will cause the values to cycle automatically. The longer the button is held, the faster they will change.

The "home" and "other" buttons let you keep two sets of location information. One for your home and one for some remote location. Once everything is set, simply click on "save" to preserve the relevant data for use the next time.

DISTANT SUNS tries to account for the proper time-zone depending on the supplied longitude. Unfortunately, due to the irregular nature of the zonal boundaries, it is impossible to be sure if the calculated figure is correct. If you are unsure of the required setting, check Appendix E. Moreover, not all countries, states or regions adjust for daylight vs. standard times. DISTANT SUNS always assumes standard time, so check the zone value for this as well. If the longitude is changed to another time-zone, the value will be recalculated for standard time.

DISTANT SUNS will allow you to enter any date between 9999 BC and 9999 AD. However, the further you go from the current date, the less accurate the calculations are likely to be. This is due to the many subtle motions in both the earth and stars. Also with this wide of time span, we come across precision limitations with the system's math libraries. Future releases of the Amiga software are expected to correct this.

If you make a mistake when changing the parameters, clicking on "reset" will return to the values present when the window was opened. "Cancel" will cause a reset of the values and close the window, while "ok" will cause the program to make use of the new data.

By selecting the rate menu item, you will be able to change the rate for the passage of time. The slider on the rate requester gives you the option of having time stand still, or speed up to



100 times normal rates (1 minute of real time will equal 100 minutes of DISTANT SUNS time). The best values fall between 7 and 15 times normal rate.

The "real-time" button will select a rate of "1," that is, the sky will update one minute's worth of motion for every minute past. "Freeze" will stop time, setting the rate to "0."

The passage of time is most noticeable when DISTANT SUNS is in Local mode, since you will be able to see the daily motion of the sky. You will be able to watch the rising and setting of the stars, sun and moon, and watch the moon move up against the stars. In Planetarium you'll be able to watch the moon's movement through the sky. However, everything else moves so slowly by comparison it won't be terribly stimulating. When in Local mode, this is very computationally expensive, so keep the rate to 0 unless you specifically need the motions. When running there will be about a 5 second pause between update calculations to permit access to the menus.

## **Titlebar**

The Titlebar option will simply turn on or off the screen's titlebar. This is so you can drag down the screen to gain access to other programs. ("left-Amiga M" will do the same for any program, without having to use the titlebar or depth gadgets).

## **Quit**

Quits the program (so what else is new?).



## Display Menu

The Display menu controls the major display elements and operation modes.

### Mode

DISTANT SUNS has three main modes for viewing the stars: Flashcard, Local, and Planetarium.

### Flashcard

This is an aid to constellation identification. Selecting **Flashcard** will turn off any identifiers and position indicators and randomly center a constellation in the screen. Now it is up to you to figure out where you're looking.

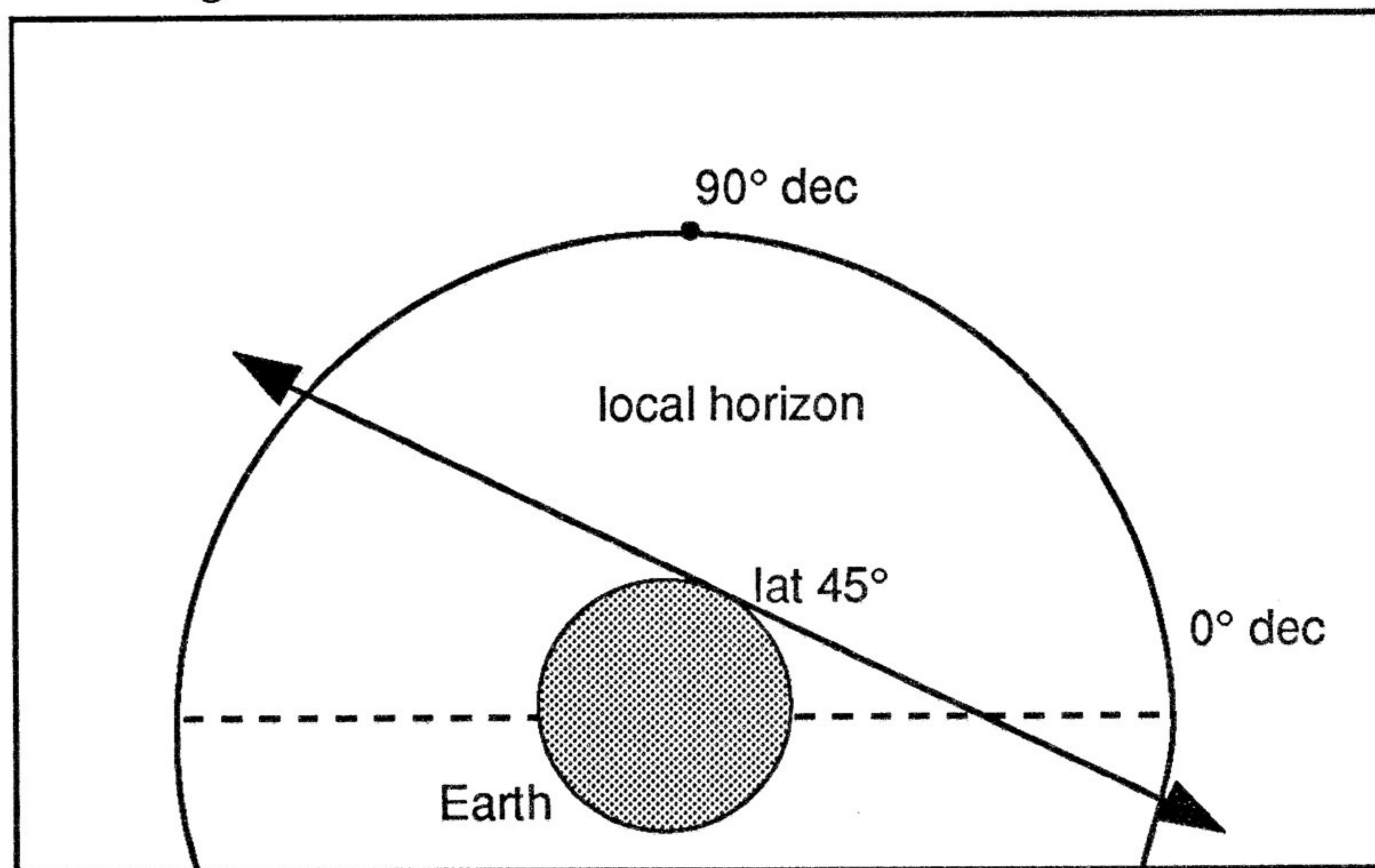
Clicking on the left mouse button will display the constellation names and viewing direction. After about 5 seconds the system will select another constellation.

### Local

In **Local** mode, the sky will be displayed as seen from the supplied time and location. Using Quickview under the System menu is the suggested way of entering Local mode to save time spent in setting up the screen. Under this mode, the sky changes from night to night and from one point on Earth to another. Furthermore, the local coordinates of the stars, their altitude and azimuth, will change as the Earth rotates. If you are in the Northern hemisphere you will notice the North Star, Polaris is at an altitude above the Northern horizon equal to your latitude (fig. 6). Were you exactly at the pole, the sky would resemble Planetarium mode.



Figure 6



## Planetarium

In **Planetarium** (the default) mode, the sky is displayed as if there were no Earth underneath to distort your perspective. This removes any ambiguities that your own location introduces.

You will no doubt notice how much slower **Local** is when compared to **Planetarium** mode. This is because **DISTANT SUNS** must do many more calculations in order to shift the perspective to your own frame of reference. And because of this, the stars will be turned off completely for scrolling while in **Local** mode.

## Constellations

The names of the constellations may be activated by selecting the "names" option. The same applies for the outlines. Each may be turned off by selecting the item a second time. Take note that generally the names are located away from the center of the constellation so as not to obscure important stars.



The 12 constellations of the Zodiac are identified by the yellow names.

## **Deep-Sky**

"Deep sky objects" are those non-stellar entities outside of our own solar-system, such as galaxies, star clusters, and so forth.

The "Messier" and "NGC" selections will display entries from two of the most popular deep-sky catalogs. The Messier catalog contains 110 entries, and the NGC or "New General Catalog" has over 10,000 listings of which the best 350 are shown here.

Since there are so many NGC objects in some areas, the labels only show with a field-of-view less than 25 degrees so as to spread them out a bit.

"Legend" opens up a window to aid you in quickly identifying the various types of objects. See the "Deep-sky" chapter for further details.

## **Field-of-View**

This selection will aid you in quickly moving to a particular field-of-view from 15 to 180 degrees.

## **Identify**

Identify activates the "point-and-identify" mode which will let you click on top of any object so as to reveal extra information. When activated the pointer will turn into a crosshair. Center the selected star and click the left mouse button. A window will now open displaying information such as the name, magnitude, exact position and sometimes explanatory notes. And in the case of the deep-sky objects, images will be available with an optional data disk. Three sample images are supplied on your disk for "M3", "M57", and "M101". (Refer to Appendix A



for their precise location.)

Be aware that this mode will get confused if there is a an outline nearby. Also, some bright stars may have a dim companion close by, and sometimes this will be detected instead of the brighter star. This will be especially noticeable when using the extended data disk due to the many more stars. A narrow FOV is recommended when using point-and-identify.

(Refer to the chapter on the stars for explanations of the data fields.)

## Landscape

Landscape will turn on an artificial horizon to simulate mountains in the distance. With this activated, your vertical scrolling is limited to a range of +/- 20 degrees in altitude. A number of options are turned off when landscape is on, namely constellation outlines. Also, Quickview's operations are now modified to quickly aim you around the horizon as before, but it will not automatically turn on the constellation names or horizon line.

## Lookdown

Lookdown will display a view of the solar-system from above. "Inner Planets" will show the orbits from Mercury to Mars. "Middle Planets" covers Earth to Jupiter, while "Outer Planets" will show you Jupiter to Pluto. Since this draws in the main screen it will be erased as soon as the screen is updated. It was done this way for two important reasons: Because it looked neater up against the stars, and having it in a separate window would have clobbered a major portion of the screen.

Lookdown will work nicely with the "Tracker" (see under "More Extras" menu), although the outer planets move too slowly to see much action.



When the date is changed, the original positions will be highlighted in green so you may compare them with the new positions.

## Markers

The Markers selection will display additional information to aid you in further understanding how the stars are laid out in the heavens. The "ecliptic" denotes the plane of the solar-system based on the earth's own orbit. "Celestial equator" will display the projection of the earth's own equator up against the sky. This is the imaginary line which separates the northern and southern hemispheres of the sky.

The "horizon-line" shows you your own horizon projected against the sky. In Local mode, it will be horizontal to the bottom of the screen. It will be 5 degrees above the true horizon in when Landscape is on. In Planetarium you will see the line at an angle because your own point of reference is itself tilted due to your latitude.

'Local altitude' will turn on an altitude line when in Local mode. This will show you the altitude above the horizon in degrees.

The RA/dec selection will overlay a right-ascension/declination grid on top of the stars, much like the grid in a star atlas.

## Move

Move supplies you two additional ways of moving around the sky: via standard sliders, or more accurately, via the direct numerical input. Right-ascension is entered hh:mm format, and declination in dd:mm (degrees:minutes). Notice that the direct-move window still asks for RA and dec even while you are in Local mode while everything else is in altitude/azimuth. While this is inconsistent, it was left this way to provide you with at least one method of locating objects via RA/dec while



in Local, (since you will rarely be given object coordinates based on your local altitude and azimuth).

## Names

This will turn on the planet names and those of over 75 of the brightest and important navigational stars.

## Search

Search will help you locate any of the planets or constellations. With Landscape on, search will respect the  $\pm 20$  degree limits on the elevation. If your target is out of range, the azimuth will be correct, but the altitude will be set at the limit.

"Search by name" will let you find many of the named objects in the database by simply typing the names in the window. The objects must be loaded into memory for it to work, which means, for instance, it will be unable to locate any deep-sky objects unless you have already selected that option.

"Search by name" includes a simple wildcard matching scheme. This means that you can type the first part of a name or identifier followed by an asterisk if you don't remember how to spell the entire name. It will search through the loaded lists, and point you towards the first item that it matches. Make sure the entry is specific enough to be unique, otherwise if you were to type in "Ursa\*" looking for Ursa Minor, it will center on Ursa Major which precedes it in the internal list. Instead you would have to type "Ursa Mi\*". Currently, common names like "Crab Nebula" are not supported.

## Show Mag

This will limit the displayed magnitude. You would probably use this only if you have the extra stars data disk. Until you have found the area of interest, you may not want to take the extra time required to display all of the stars. This option will



display only those required for the moment. That is, if you choose "5," only those stars 5th magnitude and brighter will show.

## Skylight

Selecting Skylight will make DISTANT SUNS attempt to duplicate the ambient light generated by cities or towns that wash out dimmer stars. In other words, if you live in downtown Cleveland, the sky will look a great deal different than it would from central Wyoming. In fact, many people find it hard to identify constellations in a country sky because there are just too *many* stars.

## Extras

### Color-Map

These selections will change the brightness and colors based on your needs.

"Bright" is used to counteract brightly lit rooms which could wash out the screen. This increases the intensity of everything at the cost of narrowing the differences between the brightest and dimmest stars.

"Dim" and "red" are used to preserve the "night-vision" of an amateur astronomer who might have his/her Amiga propped up next to the telescope. Night-vision is when your eyes have fully adjusted to the darkness, maximizing their sensitivity. As it takes over 30 minutes to reach this state, astronomers are reluctant to use any lights during an observing session. When necessary, red lights are traditionally used. The "red" selection will turn everything in the display (except the stars) various shades of red. For the more aesthetically oriented observer, the "dim" option was added which preserves the colors, but merely darkens them.

"Normal" will return you to the default colormap.



## Crosshair

This activates a central crosshair pinpointing the place indicated by the location in the control panel.

## Mag Chart

This will display a magnitude chart showing the magnitudes by colors instead of intensities. This will show you the magnitude distribution in a clearer fashion.

## Precession

Normally no precession is performed on the stars, since it takes a long time whether it is needed or not. Selecting "auto-precess" will cause the stellar data to be updated if the date is changed by more than 200 years. The "stars" option will precess the stars on demand, should you require greater accuracy. Any extra objects such as deep-sky or user data, will also be precessed. So the more you're displaying, the longer things will take.

Normal precession ignores the outline data. In part a time saving measure, this also permits you to compare the previous stellar positions with the new ones, by using old outlines. See the chapter on the stars for an explanation of precession.

## Print Point and Identify

You may send the point-and-identify data to your printer with this option. However, any Greek characters used in the star's designator's will not show up on the output. (see page 100)

## Save to IFF

You may take IFF screen dumps which can then be loaded into a paint program like DPaint III. You can then add any explanatory text, and optimize the colors for graphics dumps to



your printer. Note that the more complex the image (the more stars, etc.) the longer it will take to save.

Don't attempt to dump images to the DISTANT SUNS distribution disk, as there is not enough extra space for even one picture.

## **Sky Images**

The "sky-images" are what I call the sun and moon. There are two sizes which may be displayed. The smaller ones are correct for a 30 degree FOV, and are used for that and wider scenes. The larger images are correct for a 15 degree view, and are used for 15 to 25 degree views.

I added this option for those users of the original ("Classic") DISTANT SUNS (rather, Galileo) who felt that the sun and moon images were too small. "Large" will use the larger images for FOVs up to 100 degrees. "Normal" will return things to their proper perspective.

## **More Extras**

### **Star Trails**

A person's first encounter with astro-photography is usually through the taking of stellar time-exposures with a camera fixed on a tripod. The results will produce streaks, or "star trails" caused by the motion of stars across the field-of-view. This phenomenon may be simulated by going into landscape mode, setting the time rate around 7x, and then enabling this option.

### **Telescope**

This option will bring up the telescope window. By placing the cursor over any of the planets, the sun or moon, you will be able to see what a small telescope would reveal.



## Tracker

Tracker enables you to follow the motions of the planets through the sky. "Auto track" will plot the planetary positions for each day, starting from exactly one month before the current date, to one month following. Each blue dot represents a day's worth of motion, and each gold dot, a week. The sun's position will be plotted only at the week boundaries to avoid cluttering up the screen and interfering with the planet's paths.

"Manual track" will let you study the motions more closely for the current date, or any other which you may enter into the window. Use the left arrow to advance a day at a time, and the right one will move backwards a day when pressed. The "sun" button will turn on the sun's image for daily plotting along with the planets.

The moon is not plotted, because its motion is so great that even a daily plot would be meaningless. If you would like to study lunar motions, just increase the time rate to 30 or 40, sit back and watch.

## Twilight

The twilight mode is meant to simulate daytime. Turning on twilight will do different things depending on what viewing mode you are in. When in Local mode the sky will be a bright blue while the sun is "up." As the sun sets below the horizon, the sky will darken and the stars will begin to emerge.

In Planetarium, since the sun is always "up," the sky will be blue all of the time, unless of course, there is a solar-eclipse.

## User data

This option will permit you to construct your own databases to fit your own needs. (See "Creating Your Own Database.")



## What's up

The "What's Up" window will give you a quick overview of your evening's sky. See the "What's Up?" chapter for further information.

## Yale Catalog

This option will place alongside each star on the screen, the selected data field from the "Yale Bright Star Catalog."

One word of warning when using this option: Use a fairly small field-of-view, otherwise the data density could become so great, nothing will be readable. Also, the more stars on the screen, the longer the process will take. An FOV greater than 30 degrees should be avoided when using the standard database, or 15 degrees when using any of the extended databases.

"Double stars" will put a "ds" label next to any suspected star. Similarly, "Variable" will flag variable stars with a "var." Over 100 stars have associated comment files with them, so by selecting "comments," highlighted stars will be flagged with a "c." You can then use point-and-identify to read them. See chapter on the stars for more details on what each of the other fields mean.



## THE PLANETS AND THEIR MOTIONS

The planets are believed to be composed of material left over from the formation of the sun. There are two main kinds of planets: The small rocky variety illustrated by Mercury, Venus, Earth, Mars and Pluto, and the "gas giants," otherwise known as Jupiter, Saturn, Uranus and Neptune. These are known for their very dense and deep atmospheres and lack of any substantial surface. Jupiter is an especially interesting case in that it has been called a "protostar" due to the fact that it is actually radiating slightly more energy than it receives. If it was slightly more massive it might have evolved into an actual star. (See Appendix C for general planetary data.)

To the ancient astronomers the planets were called "the wanderers" since they were observed wandering about from evening to evening. Unless one were to observe the planets on a daily basis, their movements might not be noticed. However, if we were to plot their motions over a period of several weeks, we can get an idea of just what the ancients saw.

As explained in the Menus section, you can use both the "Tracker" and "Lookdown" features to gain a better grasp of planetary motions. Lookdown will show the solar-system from above, and Tracker will plot the planet's positions up against the stars as seen from Earth. Since both will work together we can perform many interesting experiments.

### Conjunctions

From time to time, the planets will appear to pass very close to each other causing a "conjunction." While they have very little scientific value, they can be quite spectacular.

As an example of a fairly recent conjunction, set the date to December 10, 1986, and the FOV to 50 degrees. Now locate the planet Mars using Search. You will notice that Mars and Jupiter are very close together. Turn on "Lookdown/



middle planets", and look how the two planets are in the same line-of-sight as seen from Earth. Activating Auto-track will show you just how the two planets moved relative to each other. Their closest approach was December 19 (9 dots from the original date). At this time they were a mere 1/2 degree apart.

You may want to use Manual-track to get a closer look.

## Opposition of Mars

Most of the time Mars is a relatively unimpressive reddish-orange smudge in smaller telescopes. However, at times of closest approach to Earth, Mars' fine details become visible. Such approaches are called "oppositions." For Mars, September 1988 brought the best opposition during the last quarter of this century. At that time, it was a mere 36 million miles away.

First, use the Telescope to view Mars for any date in 1987. During this time, the planet's angular diameter will be no more than 7 seconds (each degree is subdivided into 60 minutes, and each minute, into 60 seconds). Next, set the date to September 25, 1988, and observe again. At this time it will be over 25 seconds in diameter. Use "Lookdown/inner-planets" to verify how close both Earth and Mars really are.

## Alignments: "The Jupiter Effect"

Another "event" regarding the positions of the planets has to do with the so-called "Jupiter Effect" of several years ago. Every great while, the planets will be aligned in a narrow range of the sky. In the past, such alignments were believed to result in great world catastrophes, causing global panic. A recent throwback to that happened in early 1982, when all of the planets were visible in almost the same quadrant of the sky. For years before that time, a popular book called The Jupiter Effect claimed that this would trigger all sorts of natural disasters



culminating in a major California earthquake. This was supposed to be the result of the cumulative effect of the planets' gravity pulling on one side of the earth.

You can observe this alignment by setting the date to March 10, 1982, and opening the FOV to 90 degrees. Place Jupiter in the center of the screen. By turning on the planets' names, you will notice six of the eight planets are within the same 90 degree quadrant. Opening up to 180 degrees will reveal Venus and Mercury about 45 degrees to the left of Neptune. Now, turn on Lookdown for the 3 different settings, and you will see that if this was an alignment, it was marginal at best. Needless to say, California is still here, and a couple of authors got rich.

Another more recent alignment dealt with the four outer-planets: Saturn to Neptune. Set the date to September, 1987, and you will see that indeed, they are in the same general area of the sky. This phenomenon played an important part in the so-called "harmonic convergence," which had hordes of believers heading towards the mountain tops to usher in the "New Age."

### Retrograde Motion

Another exercise regarding planetary pathways is to study the motions of Venus and Mercury. Up until the time of the astronomer Copernicus, common belief maintained that the Earth was the center of the Universe with the Sun, Moon, planets and stars all orbiting around it. Unfortunately, a few inconsistencies crept in to upset this idyllic viewpoint. For example, the planets would, on occasion, slow up and of all things, *move backwards*.

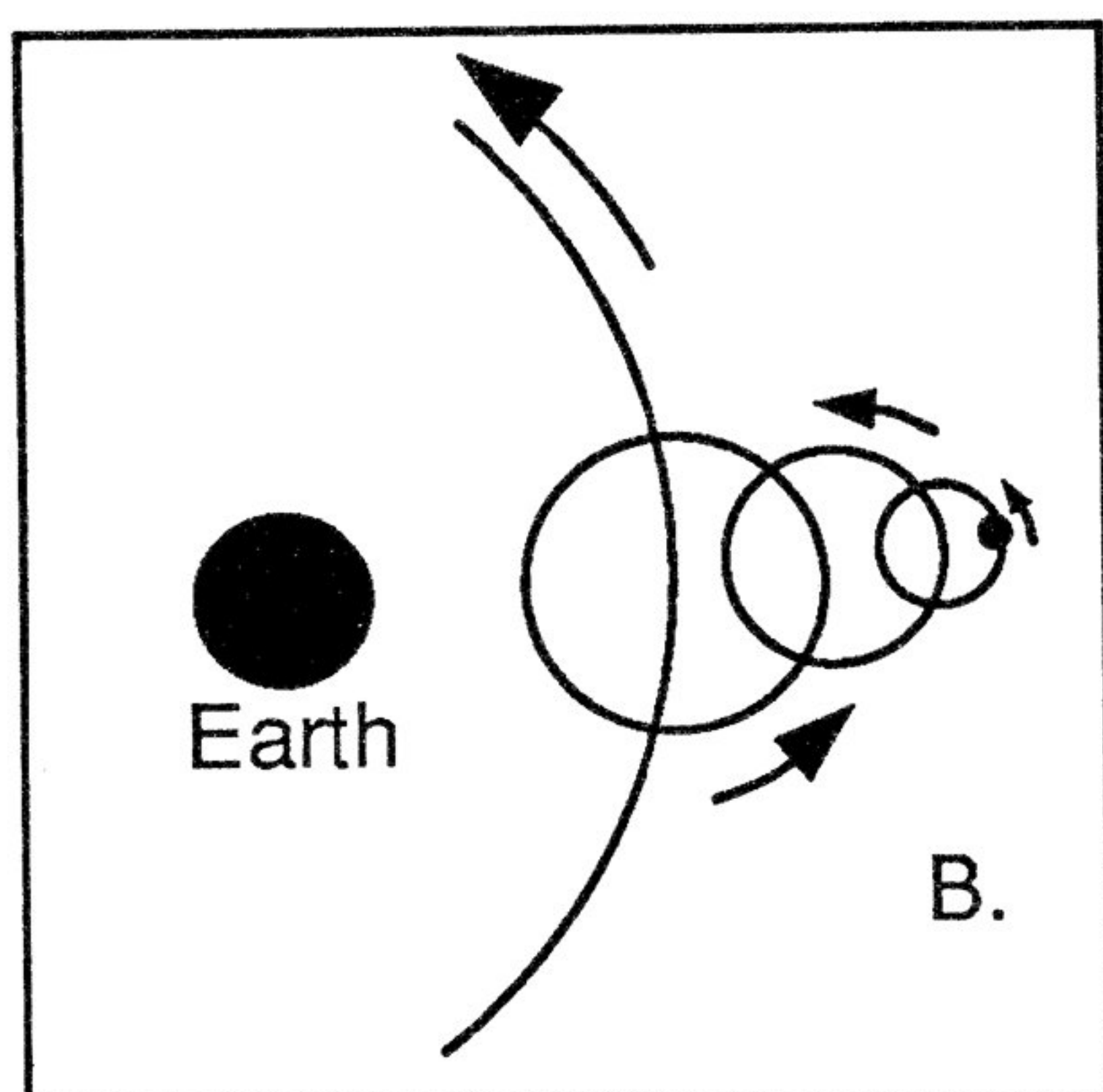
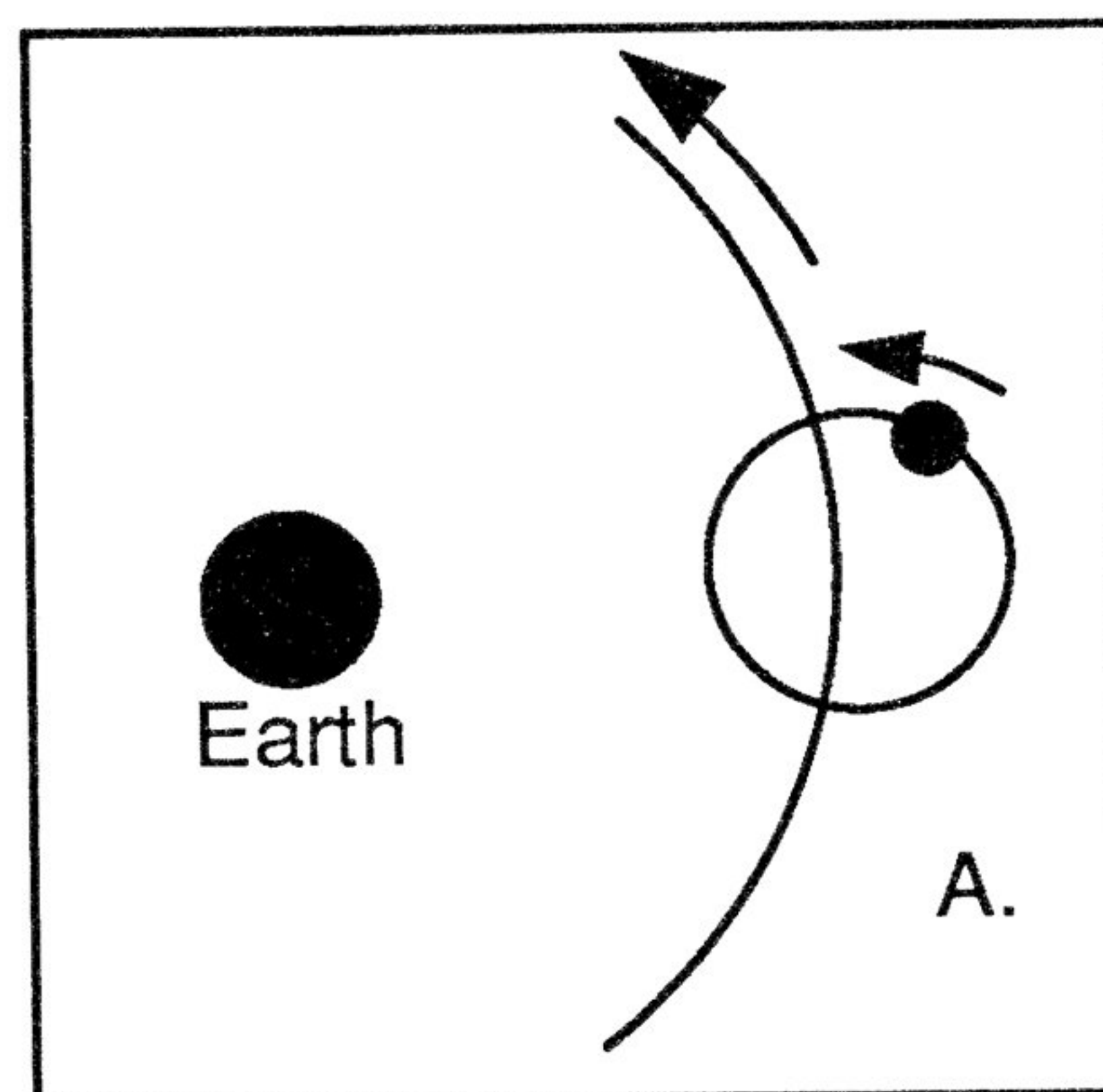
In an effort to explain this phenomenon, the astronomers of the day invented "epicycles" which forced the hapless orbs into making a small orbit on top of their main orbits, causing them to back up every so often. This still did not explain all of the movements, so more epicycles were stacked on top of the



earlier ones, (fig. 7&8). Eventually, some planets collected up to 14 levels of epicycles, but still refused to behave.

We can see this mysterious behavior (now called "retrograde motion") by observing Venus and Mercury.

Figures 7 & 8



Set the date to December 10, 1986, center Mercury in the middle of the screen, and the FOV to 60 degrees. Venus should be over at the right-hand side. Turn on the inner-planets Lookdown, view, and the planet names. Now start Auto-track.

You should notice a pair of rather unusual plots. The Lookdown view should help explain what is happening: Our own point of reference on the Earth is moving at different rates from Venus and Mercury.

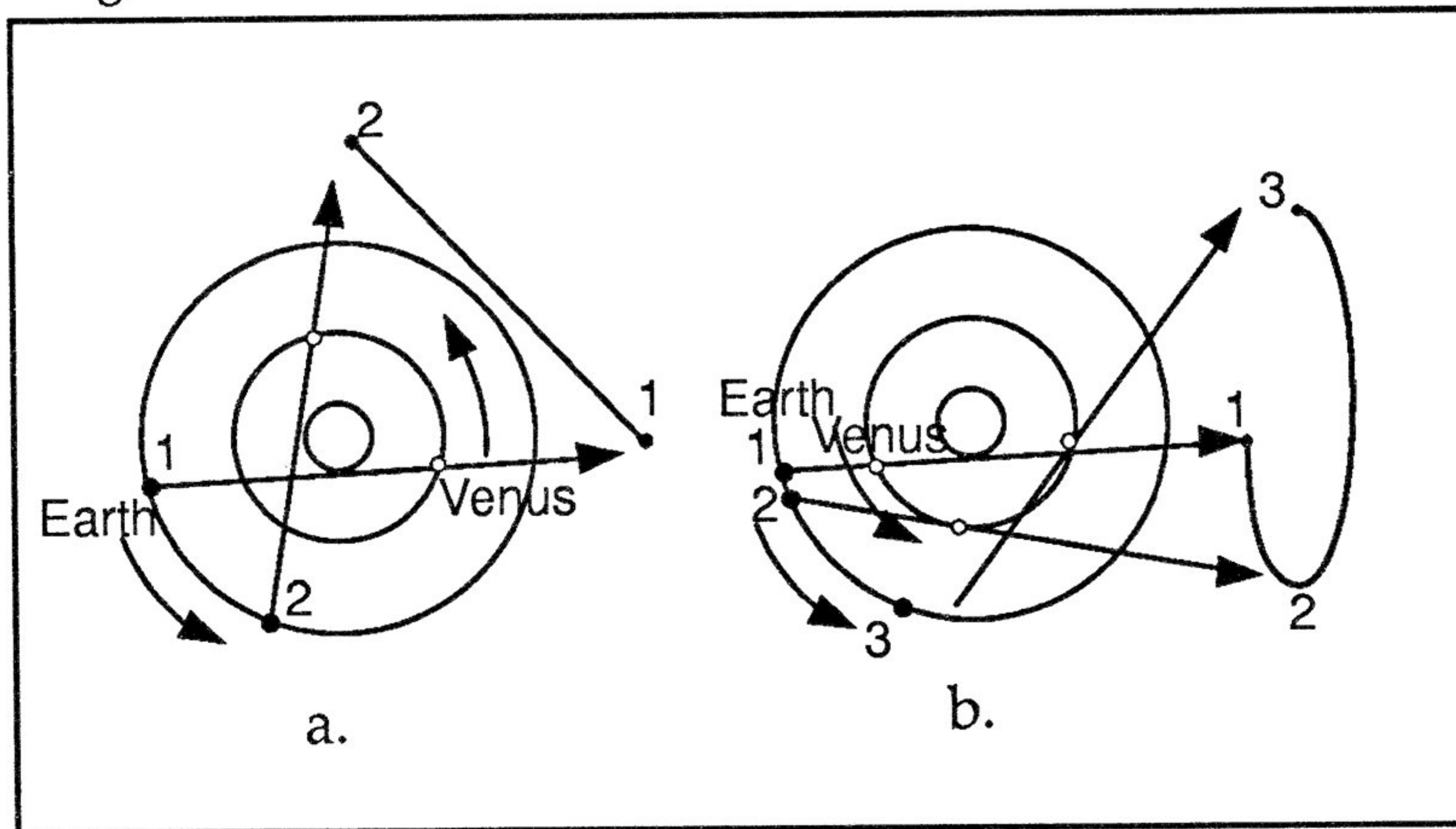
In fig. 9a, Venus will be seen to be moving in roughly a straight line. However, in fig. 9b, Venus curves around the edge of its orbit as seen from Earth, causing the apparent reverse in motion.

Another fine example of this can be seen by setting the date to September 1, 1990. Center Mercury in the screen, and turn on Auto-track as before.

No wonder the ancient astronomers were confused!



Figure 9



## Orbital Speeds

By now, you may have noticed that some planets move faster than others. This is due to many reasons. One is that the farther a planet is from the sun, the slower it must travel to remain in orbit. You may easily observe this by comparing the relative orbital speeds of the inner planets. Activate "Lookdown/inner-planets," then Auto-track. Now watch Mercury, Venus and Earth race each other around the sun.

## Planetary Eclipses

One of the rarest forms of eclipses is when one planet actually moves in front of another. One such eclipse occurred on January 19, 1591, when Mars passed in front of Jupiter. Set your location to a latitude of 48 degrees N, and a longitude of 7 degrees E (near Stuttgart, Germany, where astronomer Johannes Kepler recorded this event).

The time-zone is -1, and local time, 7:00 am. After searching for Jupiter, you'll notice both Mars and Jupiter are in the same



location. Activate the telescope and look at this more closely. Using Manual-track, you can investigate their motions more precisely.

### Planetary Phases

The moon is not the only object in the sky to exhibit phases. Venus and Mercury will show them as well. Set the date to January 1, 1987 and locate Venus. Now observe it with the telescope. You will see a crescent phase, looking much like a tiny moon, indicating that it is on our side of the sun (fig. 10a). Advance the date to March 1. Venus will look like a first quarter moon, and will be somewhat smaller as it moves away from the earth (fig 10b). Once again, advance the date ahead to June 1, 1987. This time as Venus sweeps around toward the opposite side of the sun you will see it as a "gibbous," or near full phase.

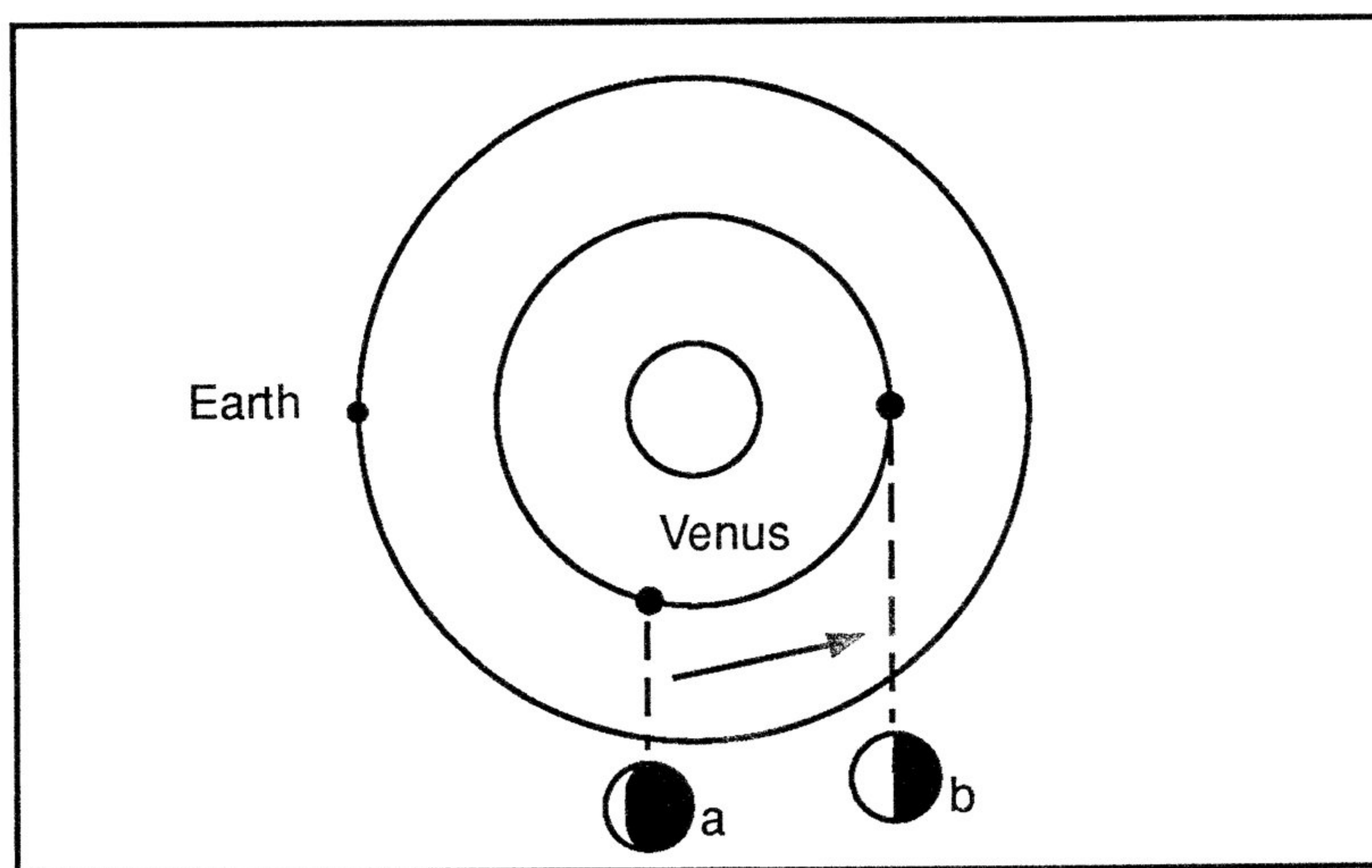


Figure 10



## Which is the furthest planet?

No doubt, you grew up learning that the furthest planet from the sun was Pluto. Not so, at least right now. Pluto's orbit is the most eccentric and most highly inclined of any of the planets. For this reason, Pluto crossed inside the orbit of Neptune in 1980, and will remain so until 1999. You can see this by using lookdown on the outer planets.

## Stellar occultations

On July 7, 1959 a very rare event took place, when the planet Venus occulted the star Regulus. This is the only time Venus will eclipse a first magnitude star for several hundred years. Use DISTANT SUNS to take a look at this by setting the date as mentioned above. Next select the "stars" option in the "Precession" sub-menu. Search for Venus, and you should notice Regulus extremely close by. Since the planet moves so fast, you'll need to juggle the time around to find the actual time of occultation for your area.

## Ecliptic

Imagine a flat surface extending out from the sun through the earth, heading out towards infinity. This forms the plane of the solar-system. Now when projected up against the sky it is known as the "ecliptic." Turn on the "ecliptic" (in the display menu) along with the names of the planets. You will quickly notice that each of the planets, (including the sun) will roughly follow the ecliptic through the sky. The planet Uranus is closest to the ecliptic, being inclined only  $3/4$ ths of a degree, while Pluto in its eccentric orbit is tilted a whopping 17 degrees. (See Appendix C for the inclinations of the other planets.)



## STARS

DISTANT SUNS uses as its primary database, the "Yale Bright Star Catalog." This is one of the most popular and commonly used databases for astronomical software. The database on the main disk contains 2200 stars down to magnitude 5.25. You can access the entire Yale catalog of 9100 stars, with one of the expansion-disks available separately.

Using either point-and-identify, or the More-Extras/Yale catalog option, you can access many of the following extra data fields supplied with the database.

### Magnitudes

The brightness of a star or other object in the sky is given by a value called the magnitude. The lower the magnitude, the brighter the object, and vice versa. Each magnitude represents an intensity of about 2.5 times less than the next lower value. The dimmest stars visible to the unaided eye are about magnitude 6.5. This means that under the best stargazing conditions, approximately 3000 stars can be seen from horizon to horizon out of a possible 6000 stars.

It would make sense that the brightest stars would be magnitude 0, but when measurements of stellar brightnesses were refined, it became necessary to indicate even greater luminosity. Thus, some of the brightest objects are actually given negative magnitudes. For example, the sun blazes away at a magnitude of -26.3, while the next brightest star, Sirius, shines at -1.46.

### B-V

"B-V" (pronounced "B minus V") is an index of the actual color of the star. The hotter, bluer stars will be negative values, and the redder, cooler stars will be positive. The range will be from about -.5 to 2.0 with 0.0 being pure white.



## Double stars

Frequently, what looks to be a single star may be resolved into two or more stars through a telescope. These are commonly called "double stars" or "binary star systems" (although many are actually multiple systems containing several stars). "Physical" doubles are those which form an actual system, orbiting around some common gravitational center. "Optical" doubles are two stars which happen to be along the same line of sight.

The orbital periods of binaries may go all the way from a matter of a few days, on up to several thousands of years or more. Unfortunately, the faster period binaries must be so close to each other, they cannot be seen with the human eye. Such systems are usually detectable via spectroscopic means, hence the name: "spectroscopic binaries." And in many cases the stars may actually be so close as to be physically touching each other.

Although most double-stars have periods much too long to observe any motion, a few are short enough to show movement within the lifetime of the average astronomer.

Some of the more well known double-stars would include Polaris (the North star) and Sirius (the brightest star, in Canis Major). Mizar, the bend in the Big Dipper's handle, is perhaps the best known double-star and is easily visible with DISTANT SUNS. With a period of several thousand years, this star is said to have been used as an eye test by American Indians.

The "double-star" selection on the Yale menu will flag any multiple stars with a "ds." Using point-and-identify you can bring up further information about the double. The first number tells the angular separation between the furthest components in arcsecs, and the second value is the difference in magnitudes between the two brightest members of the system.



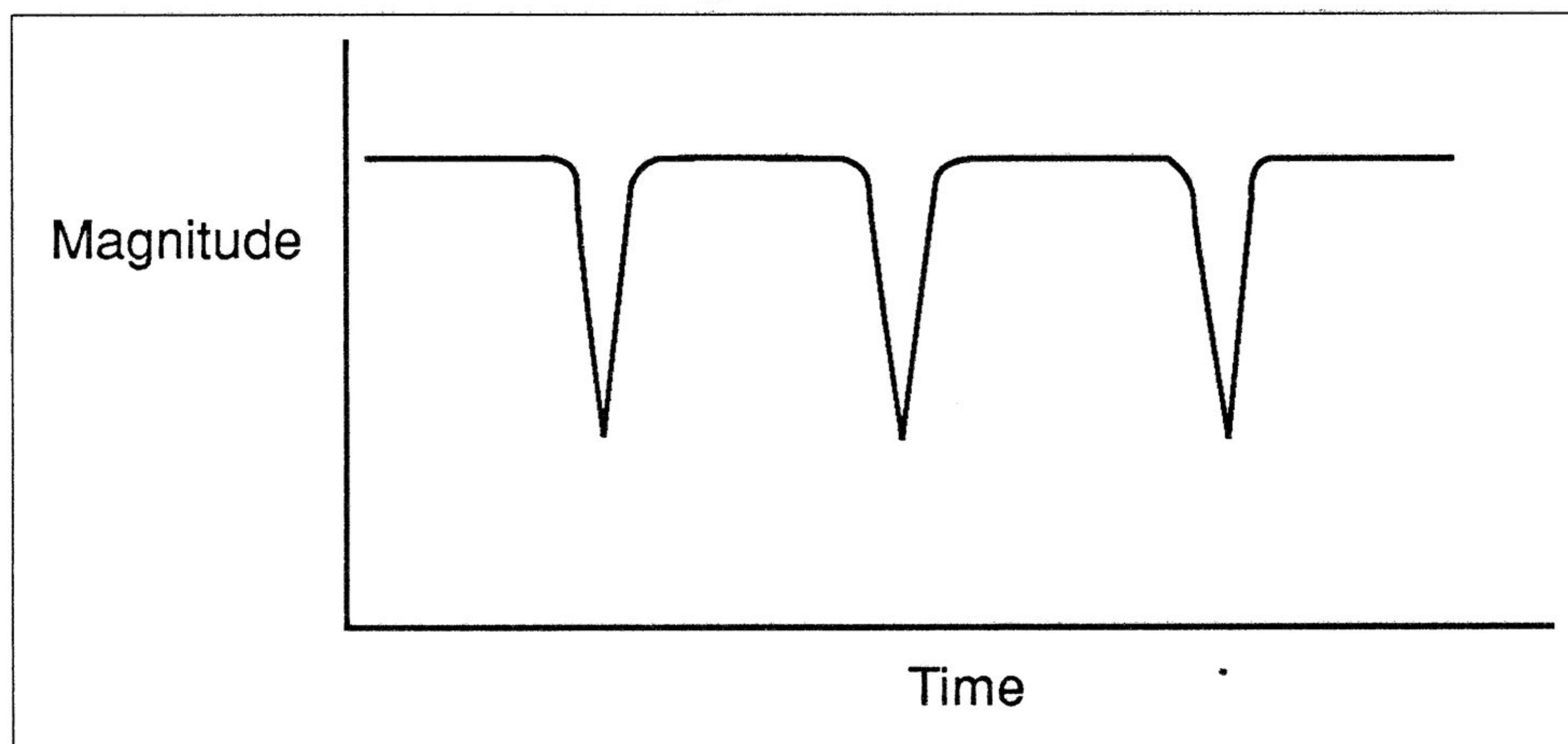
## Names

Each star will have a minimum of several different designators. DISTANT SUNS supplies up to four of these. The brightest stars have proper names, handed down to us through thousands of years of tradition and myth. A somewhat more practical method was developed in 1603, in which the main stars in each constellation were assigned a Greek letter. In general the brightest star was termed "Alpha," the next brightest, "Beta," and so on. Since then, numerous other cataloging systems have been developed usually to classify the stars according to some specific characteristic. DISTANT SUNS supplies two catalog id numbers, the Yale and one for the Henry Draper ("HD" number) catalog. By the way, all of the star comment files are keyed to the HD number. So if you would like to create your own, simply name it with the HD number followed by ".etxt" and place it in the directory "data/pidat/pietxt."

## Variable stars

Another class of star is the "variable" which actually change brightness over time. There are two main varieties: "binary variables" and "physical variables." The binaries are nothing more than double-star systems mentioned above which we

Figure 11





view edge on. The variations in brightness is therefore caused when one star eclipses the other. Such variables will have long steady light curves with short dips every few days (fig. 11).

Physical variables fluctuate by some not clearly understood physical process. Variety is something which variables find no shortage of. Some vary with a precise regular period, while others behave erratically. Many will change several magnitudes in brightness, while others may change only a few 100ths of a magnitude. Some will have long periods of several years, others, a few hundredths of a second, (as in the case of pulsars). And one variety, the "nova," varies its brightness by exploding. (The Supernova of 1987, in a matter of only hours, released 1,000 times the amount of energy of the sun over its entire 10 billion year lifespan.)

One particular kind of variable that has become very useful is the "cepheid" variety, of which about 500 examples are known. Cepheids are unusual in that their fluctuations follow a very precise set of rules. The most notable being that there is a close relationship between the period and luminosity of the stars. Knowing the period, you can determine the luminosity, and knowing the luminosity you can determine the distance when compared to their visual magnitude. Using this method astronomers are able to determine the distances to nearby galaxies.

Pulsars are one of the most interesting variable stars. The first one discovered in 1968 by the Cambridge University Observatory, had a period of a mere 1.337 seconds, an amazing amount of time when most processes in the universe are measured in terms of thousands to millions of years. Another pulsar discovered later, known as "Tau X-1" has a period of only .033 seconds! The current theories have pulsars being "neutron" stars, rotating very rapidly. Their energy is focused by a strong magnetic field into a strong beam, and is directed outward along the rotational equator, much like a lighthouse. Each time



a beam crosses our path, we receive a flash. The precision of pulsar flashes had astronomers first thinking that they had discovered an artifact from some alien civilization.

### Stellar classes

|      |                            |
|------|----------------------------|
| Ia.  | Most Luminous Supergiants  |
| Ib.  | Least Luminous Supergiants |
| II.  | Bright Giants              |
| III. | Normal Giants              |
| IV.  | Subgiants                  |
| V.   | Main Sequence              |
| VI.  | Subdwarfs                  |

Table 1

Stars are most commonly subdivided into many different classes by their chemical makeup as derived by their spectra. The spectra is the "finger print" of a star, and is revealed using a "spectroscope". A stellar spectra looks like the rainbow band of light that a common prism reveals when placed in the sunlight. By spreading out this band, dark "absorption" lines are revealed which are caused by different chemical elements in the star absorbing a particular color. Therefore helium will show up as one set of bands, and hydrogen as another set.

Figure 12 illustrates the distribution of the stars in terms of luminosity vs. spectral class. This is the famous "HR" (Hertzsprung-Russell) diagram, developed in 1913. The strong central band is called the "main sequence" as it describes about 90% of all stars. The sun would be in almost the exact center of the chart. In upper right are the "red giant" stars, large cool dudes several hundred times the size of the sun. Stretching across the top are the massive "supergiant" stars which may be as much as 50,000 times as luminous as the sun, such as Rigel in Orion. In the lower left-hand corner belong very hot, small stars such as "white dwarfs."



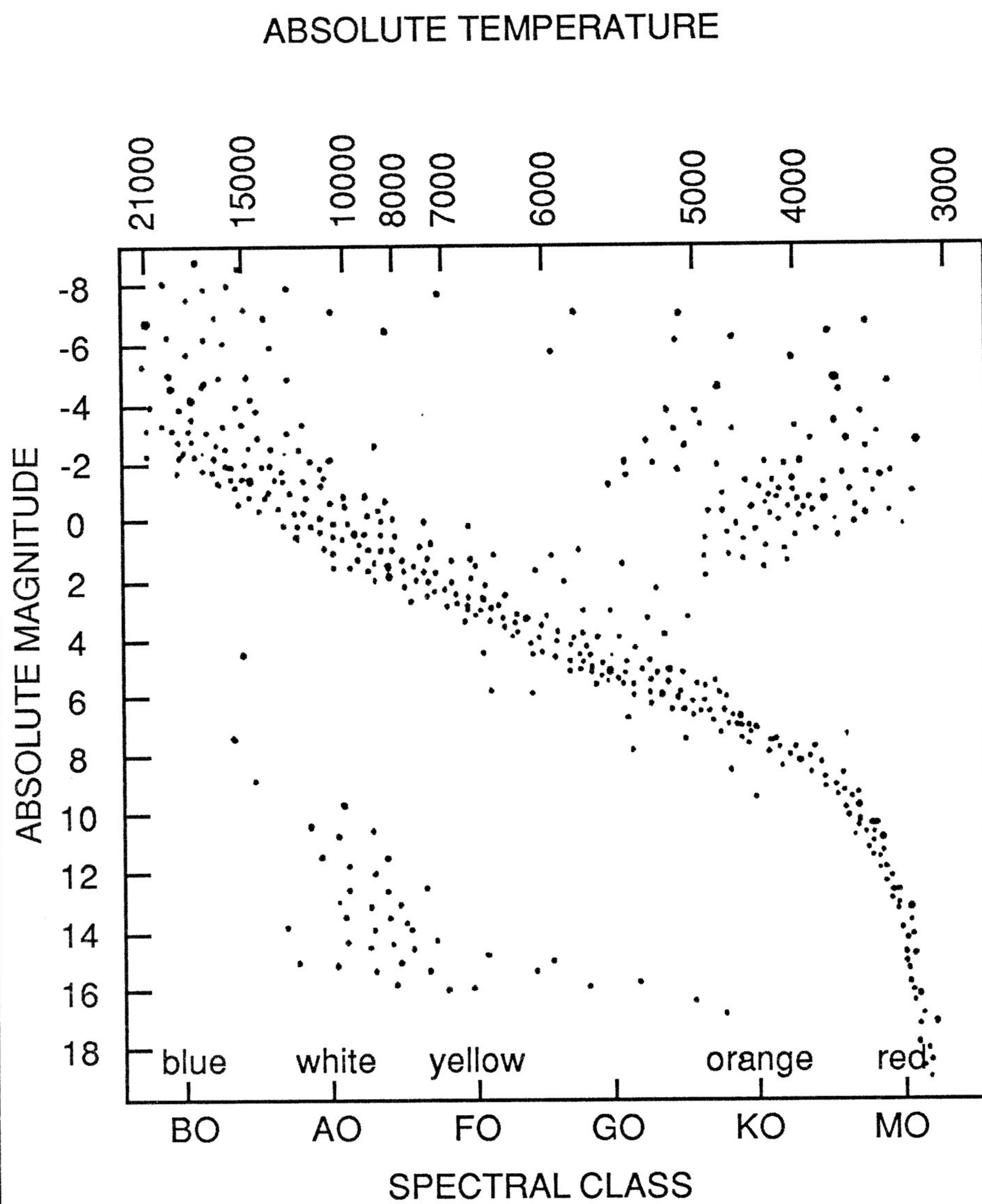


Figure 12



TABLE 2

## THE CHIEF SPECTRAL CLASSES

|   |                                                                                                                                                                                                               |
|---|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| O | Very hot (35,000 K) blue-white stars with large mass and high lumiosity. Spectral lines include ionized helium, nitrogen, oxygen, and hydrogen. Lambda Orionis, Zeta Puppis and O type stars.                 |
| B | Hot (20,000 K) blue-white stars with large mass. Spectral lines include prominent helium bands with highest intensity at B2 and disappearing at AO. Alpha Eridani, Rigal, Spica and Regulus are B type stars. |
| A | Hot (10,000 K) white stars with luminosities 50 to 100 times that of the sun. Spectral lines contain strong bands of hydrogen, while helium is missing. Altair, Sirius and Vega are A type stars.             |
| F | Warm (7,000 K) yellow-white stars. Strong calcium lines in spectrum with other metals present, and weaker hydrogen lines. Alpha Persei, Procyon and Canopus are F type stars.                                 |
| G | Warm (6,000 K) yellow stars. Metals are prominent in spectrum, with weaker hydrogen lines. The Sun, Alpha Centauri, and Capella are G type stars.                                                             |
| K | Warm (4,000 K - 4,700 K) orange stars. The spectrum contains many strong metal lines, weak hydrogen lines and the appearance of hydrocarbon lines. Alpha Ursa Majoris, Pollux and Arcturus are K type stars.  |
| M | Cooler (2,500 K - 3,000 K) red stars. Wide spectral bands from titanium oxide, with many other strong metallic lines. Many show bright hydrogen lines. Betelgeuse, Mira and Antares are type M stars.         |
| N | Deep red cool (2,500 K) giants. Carbon spectral lines appear. Mostly variable stars. Y Canum Venaticorum, R Leporis and S Cephei are type N stars.                                                            |
| R | Orange red stars similar to type N, but warmer. Carbon bands are weaker. May be path through which type G become type N. RU Virginis and S Camelopardi are type R stars.                                      |
| S | Red stars similar to type M but with zirconium oxide bands replacing titanium oxide. Complex spectra, usually variable, with hydrogen emission lines. R Cygni is a type S star.                               |
| W | Hot (50,000 K+) blue giants, known as Wolf-Rayet stars. High luminosities, similar to type O but with expanding gaseous shell and extremely turbulent atmosphere. Gamma Velorum is a type W star.             |



The letters O, B, A, F, G, K and M are used to identify the main classes (table 2). Finer distinctions are marked by the numbers 0 to 9 following the letter. For instance, our sun is spectral class G2, or Rigel is B8. Still finer classifications are required due to differences in luminosities within a particular spectral type. These are given by the "MK" identifiers shown in table 1. Therefore the complete class of the sun is G2 V, while Rigel is B8 Ia.

## Stellar Motions

While they appear unmoving to us, the stars along with everything else, never stand still. The two kinds of stellar motions DISTANT SUNS deals with are "radial velocity" (speed coming towards or going away from us) and "proper motion" (movement against a fixed background).

Radial velocity, measured in kilometers/second, is determined from the star's all important spectra. As a star varies its distance to us, the "Doppler effect" takes hold and shifts the spectral lines mentioned above. If a star is receding, or going away from us, the lines are shifted towards the red end of the spectrum, hence the name "red shift." If it is approaching us, the lines move towards the violet end, the "Blue Shift." The red shift has indicated that the entire universe is expanding, much like spots do on the surface of an inflating balloon.

On the other hand is proper motion. This is measured in arc-seconds/year of angular motion up against "fixed" objects in the sky. Naturally, the closest stars would be seen to have the fastest proper motions. Barnard's Star (the 3rd closest star at 6 light years) in Ophiuchus is the champ. It can be easily seen zipping through the heavens at the breakneck speed of 1 degree every 351 years.

There is yet another motion, called precession, which has the unfortunate effect of making all star atlases of the world obsolete every 100 years or so. This phenomenon is a subtle



motion, or wobble of the earth's axis, where one "wob" takes some 25,800 years. All stellar positions will gradually shift as a result of this. That is why stellar data is prefaced by the "epoch," or the year for which it is most valid. For instance, DISTANT SUNS' database is epoch 2000, meaning that the positions of the stars are correct for the year 2000 AD. This doesn't make the data useless for the current year, since the motions are so slow, new epochs are calculated only every 50 years or so.

One by-product of precession is that our current North Star, Polaris, is only temporary. In the year 4145 AD, the star Gamma Cephei will hold the honors. DISTANT SUNS can demonstrate this with the precession option in the Extras menu. "Auto-precess" will cause the epoch to be recalculated for every 200 years change in the date. The default is "off." This was done since it takes a long time to recalculate to new positions, so I didn't want to waste the time doing so if it really wasn't needed. "Stars" will precess the stars on demand, should you want resolution finer than the 200 year boundary. "Outlines" will precess the constellation outlines on demand. This saves the time it would take in recalculating the outlines if all you wanted to do is to look at the new stellar positions. Also, by not precessing the outlines automatically you can do a "before and after" look at the sky in one shot. Try this by centering Polaris and setting the FOV to about 60 degrees. Turn on auto-precess and set the year to 4145 AD as mentioned above. When the new positions are recalculated, and stars refreshed, turn on the outlines. What is wrong with this picture? There aren't any stars marking the ends of the lines. You should be able to make out the outline for the Little Dipper where it used to be, with the end of the handle pointing out Polaris's former location. Nearby is Gamma Cephei, (use "identify" to verify this). Now precess the outlines, and things should begin to look normal.

Another more obvious motion of the stars is caused by the rotation of the earth. If you were to take a time exposure of the night sky with the camera aimed towards Polaris you would



get a picture of streaks, or "star-trails" circling around the star. Since Polaris represents the northern "axis" of our hollow sphere model of the universe, it's apparent that the stars should appear to rotate around this point. You can see this for yourself by going into Landscape mode and setting the time rate to about 7x. Turn on the Star-trails option to simulate time exposures. Now sit back and watch.



## DEEP SKY OBJECTS

"Deep-sky" objects are non-stellar objects outside of our solar-system. These include such things as star-clusters, galaxies and nebulas.

### Star Clusters

Star clusters are groupings of stars which are gravitationally dependent on each other. Open clusters are loosely formed collections. The Pleiades (M45 in Taurus) or the Hyadies (the head of Taurus), are fine examples of these. In some cases open clusters might contain fewer than a dozen stars. On the other hand there are "globular clusters," which are very tight spherical formations containing hundreds of thousands of stars. "M13" in Hercules is one of the most notable examples of this.

Since star clusters are a part of our own galaxy, they will mark the regions of the Milky Way. As a demonstration of this, open the FOV in DISTANT SUNS to 180 degrees for a fish-eye view of the Universe. Center Scorpius, and turn on the NGC objects. You will notice the globular and open star clusters (green and red points) localized along a particular strip of the sky. This is where you would see the Milky Way on a dark night. The region over at the far right is above the plane of the galaxy. Without the Milky Way to block the rest of the Universe, you will see a heavy concentration of galaxies over on the edge of the view. Now center this and you'll be looking straight into the middle of the Virgo galactic cluster. Over on the lower right-hand side of the screen you will see a gathering of open-clusters. Once again, you're back into the Milky Way, looking away from the center into one of the spiral arms. And once again, the outside galaxies are blocked from view. One can only wonder what spectacular views lie on the other side that we shall never see.



## Galaxies

Galaxies are often referred to as "cities of stars," the most famous being our own Milky Way. Galaxies typically play host to billions of stars.

Galaxies such as the Milky Way or the Andromeda Galaxy (M31) are classified as "spiral" because of their strong disk-shaped appearance (fig. 13a). Many spirals in fact show distinct arms curving out from the core, looking much like a giant celestial whirlpool.

Elliptical galaxies are those which have no strong disk but still maintain a rounded form (fig 13b).

Irregular galaxies have no form whatsoever (fig. 13c). The Small Magellenic Cloud in the Southern skies is an example of one of these.

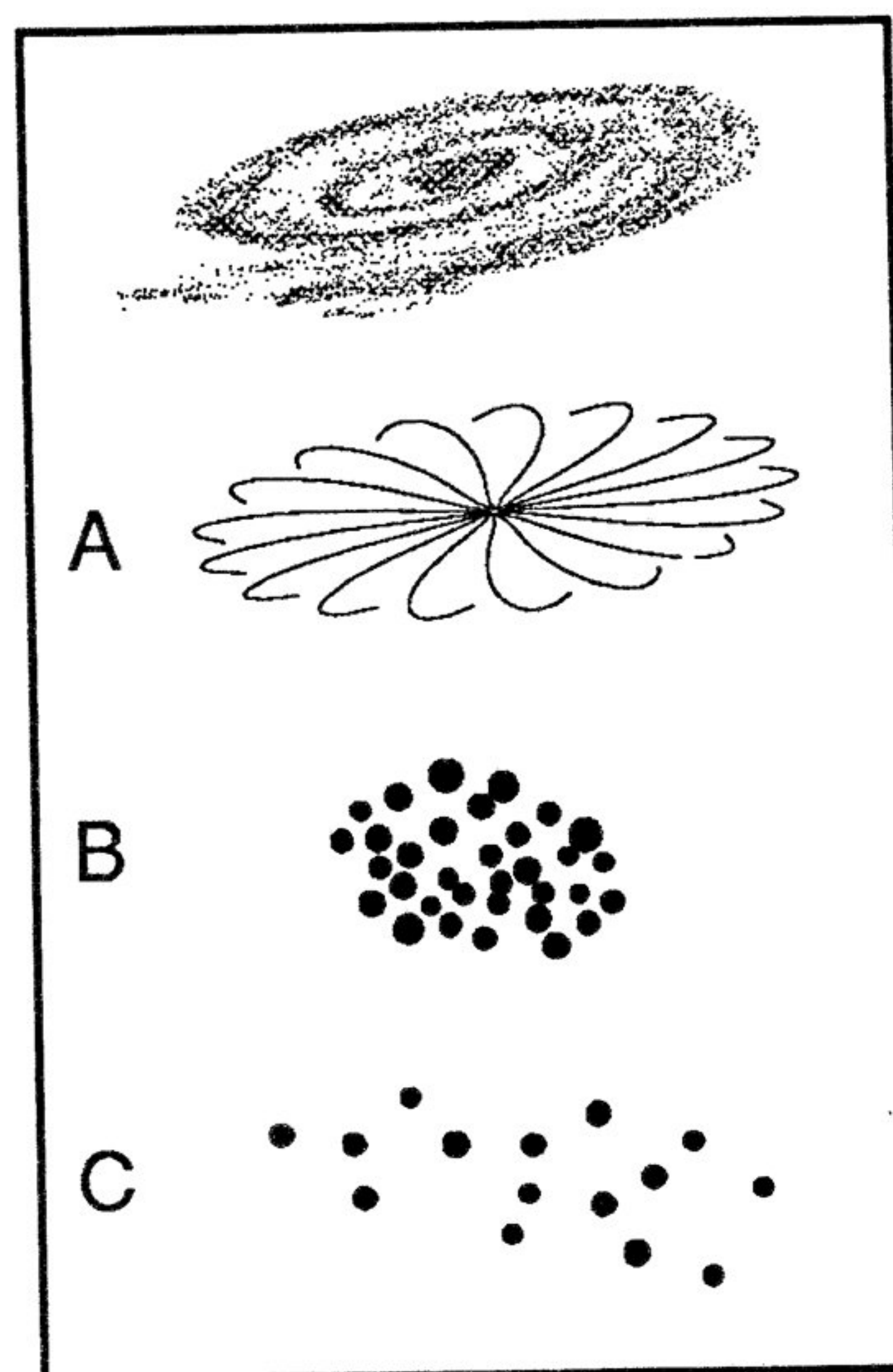


FIGURE 13

## Nebula

Nebulas are interstellar dust and gas clouds which provide raw materials for new stars. It is believed that over a third of our galaxy's mass is in this form. The most well-known nebula is the remarkably beautiful M42 in the constellation of Orion. This is called a "diffuse nebula" because of its loose irregular shape.

Planetary nebulas are those which have a rounded planet-like appearance. These usually result from a star which at one time became unstable and exploded (a nova), shedding its outer layers. The Ring Nebula in Lyra (M57) and Rosette Nebula in Monoceros (NGC2237) are fine examples of such objects.



Visible in even the smallest telescopes, the Ring Nebula looks like an intergalactic smoke ring blown there perhaps by a relaxing deity.

Nebulas may either be dark or bright. The dark ones, such as the famous Horsehead Nebula in Orion, look much like "holes in the sky," obscuring everything behind them. This is because they simply have no stars near enough to illuminate them. For this reason, some feel that the dark nebulas represent the original matter left over from the creation of the Universe.

On the other hand, the bright nebulas frequently have been called "stellar nurseries." In the center of the 30 light-year wide Orion Nebula for instance, objects have been observed which are believed to be stars in the actual process of forming.

Nebulas are typically composed of hydrogen and helium, with traces of carbon, oxygen and nitrogen.

### Deep-Sky Catalogs

DISTANT SUNS makes use of two of the main deep-sky catalogs. The first one is called the "Messier Catalog" after the French astronomer Charles Messier, and contains 110 entries. Compiled in 1781, the catalog was developed as an aid to comet hunters who might mistake the faint smudge of a galaxy or nebula for a comet. This listing contains the most famous objects in the Northern skies.

The other set of objects belong to the New General Catalog, "NGC," which comprises over 10,000 entries. DISTANT SUNS will display the best 340 of these (see Appendix B).

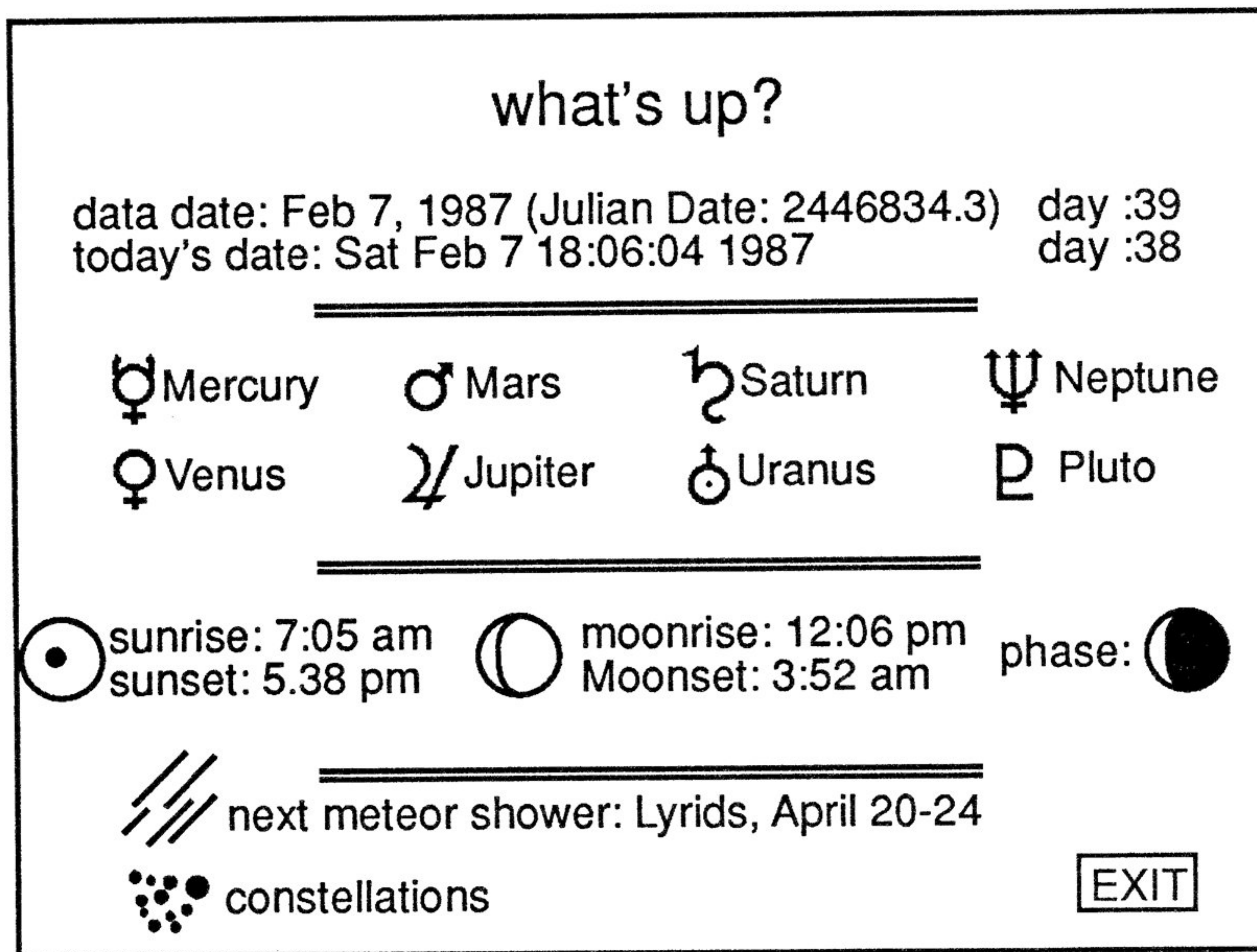
Because the long NGC catalog numbers could interfere with each other with wider FOVs, they aren't drawn until it is less than 30 degrees. Otherwise the objects will be shown merely as color-coded pinpoints.



## WHAT'S UP?

The "What's Up?" screen will present you with a quick overview of the evening's sky (fig. 14). At the top you will find the date read from the Amiga's internal clock "today's date", the date you've set using DISTANT SUNS' date/time requestor "display date," and the number of days from the start of the year "day."

Figure 14



Also at the top is the "Julian date". This is the number of days from the "fundamental epoch" of Greenwich noon, January 1, 4713 BC. With the vagaries of traditional calendars, and the need for precise calculations, the Julian date enables astronomers to establish exact times for particular events. Within DISTANT SUNS every date is converted to the Julian date before a calculation can be done.



The status of the planets is shown in the center of the screen. The color of the planet's name will tell you approximately what time it will be visible. Red planets are for the lazy observer, as they are observable before midnight. Yellow planets are for the more hardy observer, since they are only visible between local midnight and dawn. The blue planets are not visible at all during the nighttime hours.

More precise information may be retrieved by clicking on the planet's symbol, opening up an additional window (fig. 15). As to be expected, you are given the coordinates and rise/set times. You are also given the distance to the planet in both "astronomical units" and "light distance."

An astronomical unit ("AU") is 93,000,000 miles, the approximate distance from the earth to the sun, and is commonly used in giving distances within the solar system. Light distance measures the length of time required for light or (radio signals) to travel from the earth to the planet.

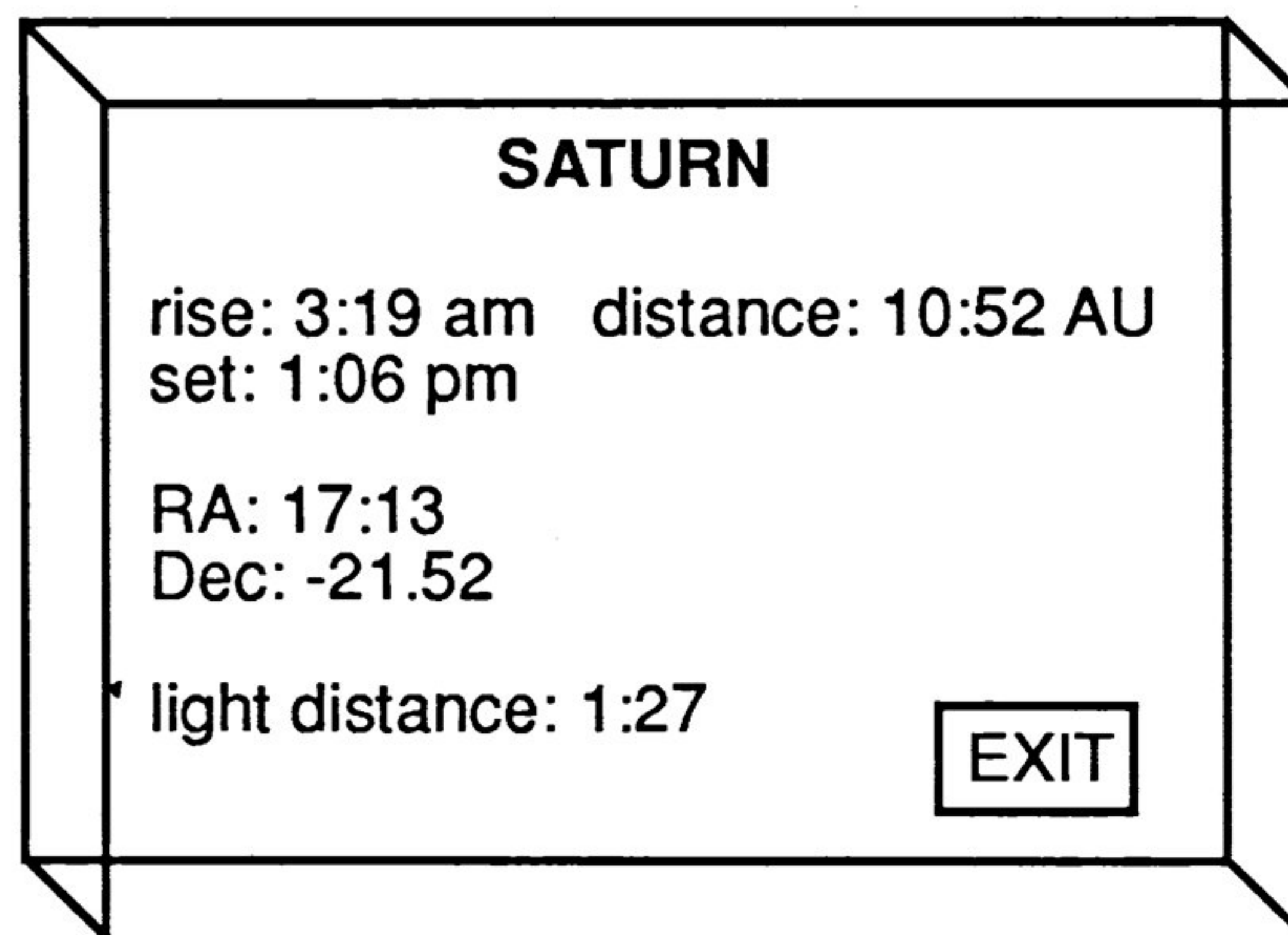


Figure 15

The light distance plays an important part in how spacecraft such as Voyager or Galileo are controlled. For instance, when Voyager flew by Neptune in August, 1989, it took radio signals over four hours to reach it. This meant that if something in the spacecraft needed to be activated by ground control, it would take eight hours to find out whether the spacecraft did as commanded.



Immediately below the planets are the rise/set times of the sun and moon. To the right of this block is an image showing the current lunar phase. A moon which is getting larger in size is said to be "waxing" until it is full. After that, it is "waning." (See the chapter on the moon for more details.)

At the bottom of the screen is information about upcoming meteor showers. By clicking on the symbol, you'll see further information about the upcoming shower. (See the chapter on Meteors.)

The last item in the screen are rise/set times for the constellations. Not all constellations are visible from every point on the earth however.



## METEORS

DISTANT SUNS will keep track of the next meteor shower for you by use of the meteor button in the What's Up window.

Meteors are small solid particles in orbit around the sun and, in many cases, believed to be debris left by passing comets. For this reason meteors tend to be grouped together in comet-like orbits and often have been linked to known comets. It is when the earth passes through one of these streams that a meteor shower occurs as the particles burn up in our atmosphere. On any night, the average observer should be able to see about five "stray" meteors per hour. The typical shower will generally triple that rate while the best ones (such as the Persiids of August and Geminids in December) may have 50 or more (see Appendix E).

The distribution of meteors along their orbits is not uniform. Therefore, what may have been a bland shower one year might be a memorable event the next. The most notable shower of this sort is the Leonids of November. Usually the Leonids produce about 15 or 20 streakers an hour. But early one morning in November 1966, along the western coast of the United States, rates approaching *one-hundred fifty-thousand* per hour were reported. This was a repeat of the famous 1833 shower which prompted one 19th century writer to exclaim: "Never did rain fall much thicker than the meteors fell to the earth. . .".

Occasionally, meteors the size of small rocks will join the fray, producing what is called a fireball. The bigger ones may be seen to break apart forming two or more fiery trails. The biggest of these might survive their entry and strike the earth. These meteors then become known as meteorites. The mile wide Barranger Crater in Arizona is a dramatic example of this.

The names of the showers are derived from the area of the sky from which the meteors appear to radiate (hence the name



"radiant"), like spokes in a wheel. Therefore the Leonids would appear to be coming from the constellation of Leo.

The best time to observe a shower is after about 2:00 a.m. local time until dawn. Since the meteors can appear in any part of the sky, a telescope or pair of binoculars would only hinder the viewing.



## SUN AND THE MOON

Without a doubt, the two most prominent objects in the sky are the sun and the moon. In the past they were seen as gods to be appeased or celestial lovers to write stories about. Their influence on our lives is obvious. From control of the tides, seasons, to weather patterns, nearly everything we do can be tied to the sun and to a lesser degree, the moon.

### Sun

**[WARNING: If you value your eyesight, don't ever look directly at the sun without the aid of a specially equipped telescope!]**

When we talk of the stars, most will think of the night and the scintillating pinpoints of light scattered across the sky. But the sun is also one of the pinpoints, just a whole lot closer. An unremarkable star, of average size (800,000 miles in diameter), the sun provides us a closeup opportunity to study stellar processes.

The "surface" of the sun is approximately 10,000 degrees F (as compared to the interior which can reach millions of degrees!) Sunspots are compact regions which are cooler, dipping down to a brisk 7,000 degrees. These are areas currently going through intense magnetic disturbances. There is usually a lighter fringe called the "penumbra" surrounding a darker core, or "umbra." Since the sun rotates in about 27 days, it is possible to observe the spots travel across the disk, disappear, then return days later (if they haven't vanished from the surface). Sunspot activity follows an 11 year cycle. As of this writing, we've just started cycle 22, which will peak around 1991. During the cycle minimum, days may go by with no spots visible at all, whereas at the peak, dozens of patches may be seen. Using DISTANT SUNS' telescope, you may see what sunspots look like. Unfortunately, the image is static so don't expect to see things change.



The activity causing sunspots directly affects the physical properties of our atmosphere. It is responsible for the aurora ("Northern" or "Southern" lights), and for the way radio waves travel around the world. Shortwave listeners are familiar with the phenomenon of how on some days their favorite radio station may be strong, and on others, it might not be audible at all.

You may observe sunspots directly only through the use of specifically modified telescopes, and then, only with filters placed over the end of the scope, and not the eyepiece. For amateur telescopes, use a "reflective" filter, as opposed to the absorption variety ("smoked glass") which can still pass dangerous invisible UV and infrared light.

### Midnight Sun

The maximum altitude that the sun reaches in the sky is based on two things: 1) the latitude of your location and 2) the tilt of the earth's axis. By changing the latitude in DISTANT SUNS, you will notice how the sun's altitude varies, the closer to the equator the higher it is and vice-versa. It is the earth's tilt that can produce one of the more disorienting phenomena: That of the "midnight sun." For instance, during the summer, the sun never sets for any observers within 23 degrees of the North pole, but instead it travels in a loop just above the horizon. What has happened is that the observer has moved out of the region that can be shaded by the earth in its rotation to a part that cannot be shaded (fig. 16).

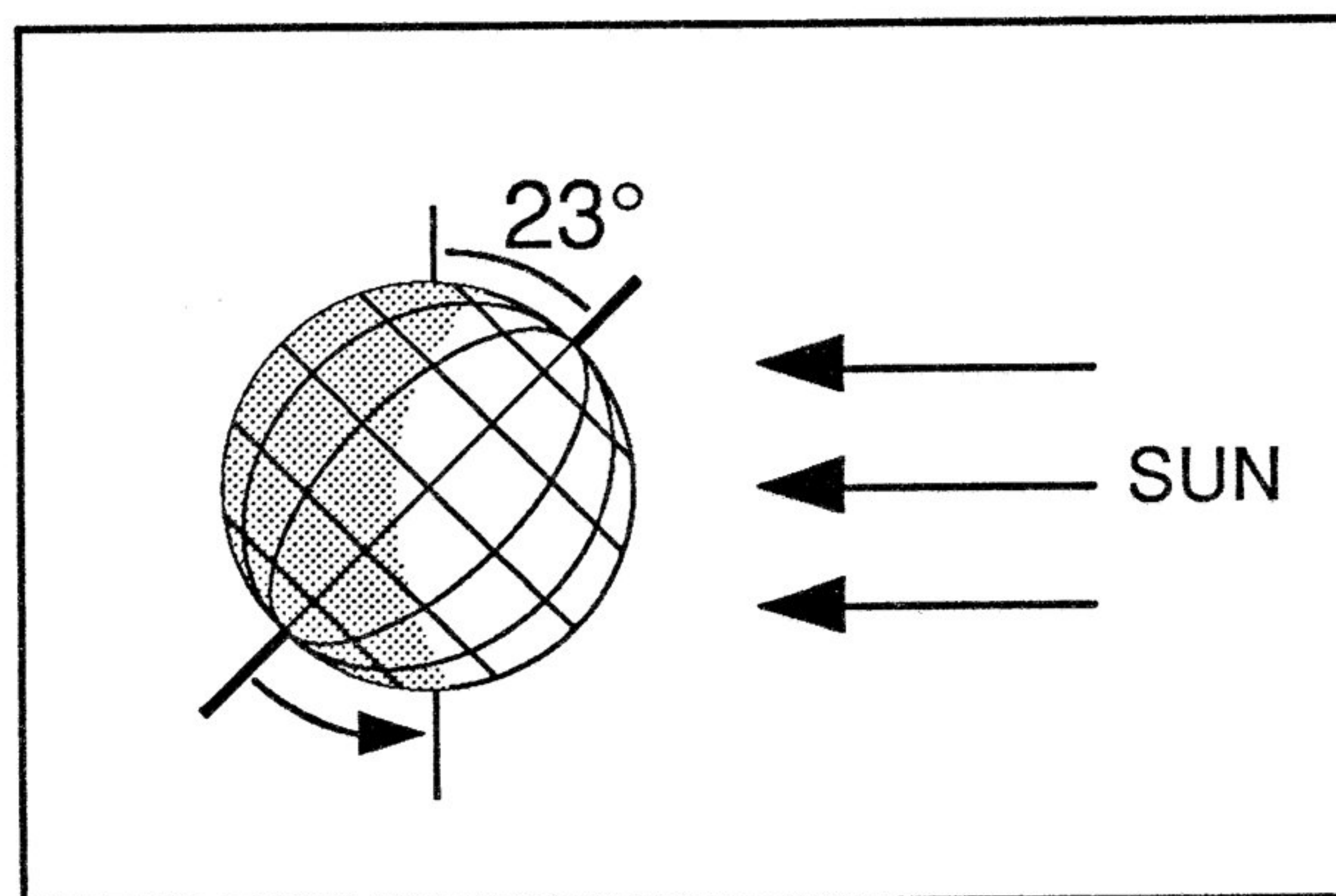


Figure 16



You can use DISTANT SUNS to demonstrate this by setting the latitude to 67 degrees (23 degrees away from the North Pole), and the date and time to June 20 (the first day of summer) at 12:01 am. Now go into Landscape mode, and search for the sun. You should see it above the horizon (if you can't see it, the mountains might be in the way, so go over to local mode and turn on the horizon line). Now turn up the time-rate to 50x or more, and you'll see the sun skirt around the horizon going from 0 degrees to 23 degrees in altitude.

## Solar Eclipses

One of the most beautiful and rarest of all celestial events is the solar eclipse. A solar eclipse occurs whenever the moon passes between the sun and the earth, casting its shadow onto the surface of the Earth.

DISTANT SUNS can be used to reproduce recent eclipses. The last total solar eclipse to happen over the mainland United States took place on the morning of February 26, 1979.

If you want to "see" this particular eclipse, set the location to 117 degrees W. longitude, 46 degrees North latitude, and the time-zone to +8.0 hours.

Now set the FOV to 30 degrees and the time to 7:00 AM. Search for the sun. You should see the new moon slightly to the lower right of the sun.

Change the time to 7:30 and you'll notice the moon just beginning to cover up the sun. Change the time to 8:25, and you should now be at totality.

I would recommend going to see an eclipse in person. One of the unfortunate facts about solar eclipses is that the pathway of the lunar shadow is so narrow, being no more than 80 or 100 miles wide. Totality lasts from only a few seconds to a maximum of 7 min 40 sec. The best way to see one for a



novice would be to go in a package deal. Such "Eclipse tours" are commonly advertised in the astronomy magazines. There are between two and five solar eclipses per year, and each is preceded or followed by a lunar eclipse.

## Moon

Orbiting around the earth at an approximate distance of 250,000 miles is the moon. With a diameter of about 2100 miles, over 1/4 that of the earth, the earth-moon system has sometimes been called "twin-planets." The moon orbits the earth with a period of 27.3 days, the same length as its day. As a result of this, it always keeps the same face towards the earth.

The origins of the moon are still shrouded in mystery. Some feel that it might have formed with the earth, others think that it was "captured" by the earth when it got too close. No matter where it came from, the moon easily provides one of the most dramatic views through any telescope or even a pair of binoculars. The rough jagged mountain ranges bordering the smooth Maria, or "Seas," provide a stunning sight when lit from the side. Craters within craters, lava flows, and the lunar "rilles" (lava "river beds") may be seen through even the simplest of telescopes.

As a result of its orbiting around us, the moon exhibits the familiar phases. When it is growing in size, it is said to be "waxing" until it is full. After that it is "waning". The phases are created by the varying angles at which we see the moon. That is, if the moon is to our side in its orbit, we will see one half of its face illuminated. If it is near to the sun, we are in effect, behind it, and so will see no part of it illuminated (fig. 17).

DISTANT SUNS' telescope will show you approximately what you would see through a small amateur instrument. Of course, a lot of the sharpness is lost because of the monitor's resolution, but you should get an idea of what it is like.



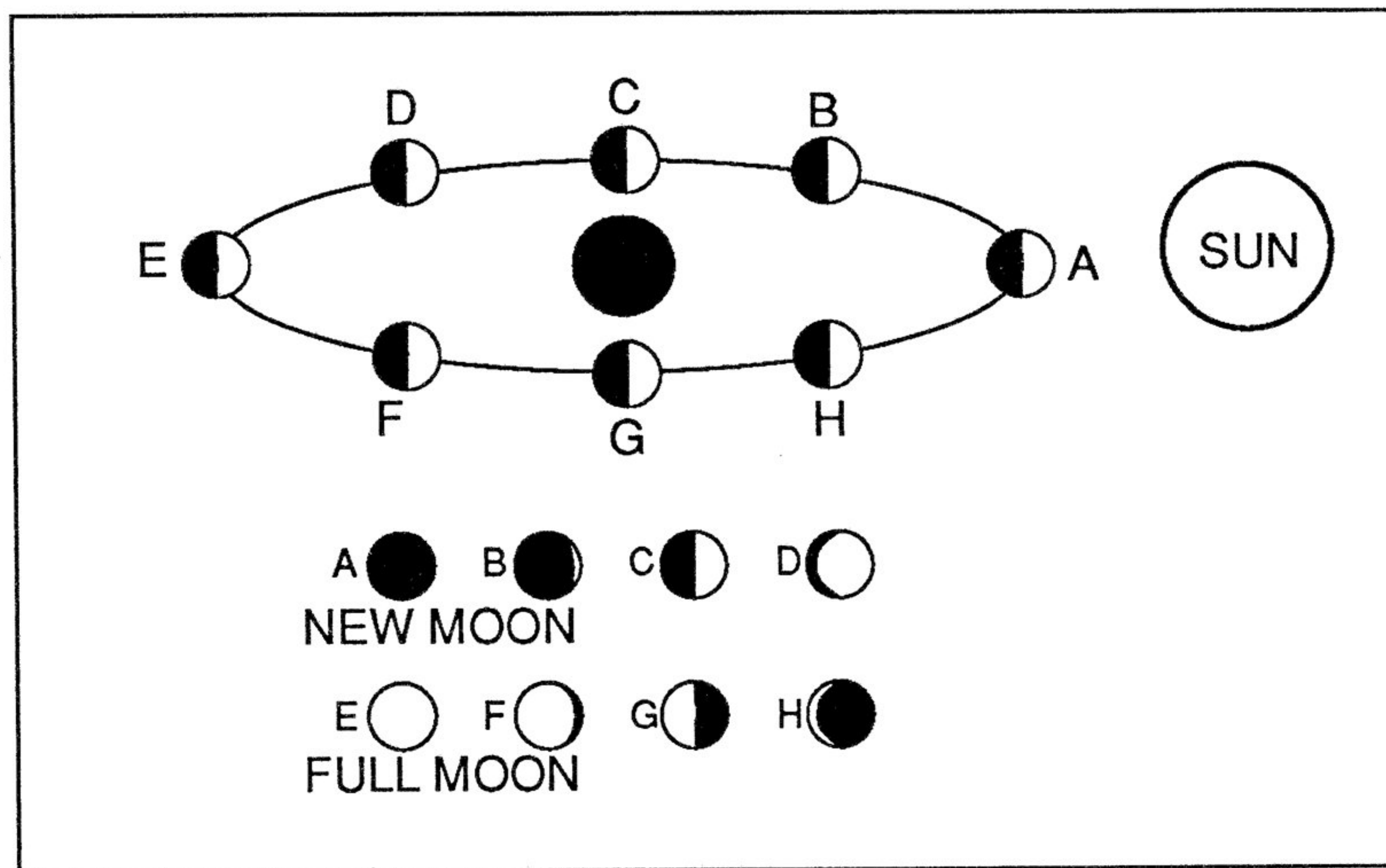


Figure 17

You may be wondering why we don't get an eclipse every time the moon is new. The plane of the moon's orbit is not exactly in line with the earth's, but is in fact tilted about 5 degrees. The two intersection points of the plane with the earth's are called "nodes." When the new moon is near either one of these points, it will be in line with the sun and therefore create an eclipse, otherwise it will be too far above or below to block the sun.



## CREATING YOUR OWN DATABASE

DISTANT SUNS is an open-ended package in that it will let you expand the database to suit your own needs. When done, the "User Objects" feature in the More Extras menu may be used to display them or not. Data is entered using an editor such as "ed," or "emacs" which is supplied on the Extras disk that came with your machine.

This feature might be used to add in variable stars should you be a member of the AAVSO. Or if a new comet is discovered the weekly positions could be entered in from data published in a magazine or newspaper. You are provided with a sample file located in the directory: `data/userdata` and called "`ud_stellar.dat`".

A sample entry might look like:

```
2 1445.3 9.98 2 OQ172
```

The "2" is a unique serial index number, beginning with "0" and going on up to 499, for a total of 500 objects. The next number, 1445.3, is the Right Ascension in the format of hhmm.mm. So this object is at an RA of 14 hours, 45.3 minutes. Next is the declination in decimal degrees. The "2" is the color of the object. The last field, "OQ172," is the label which will show up when the objects are activated. The label is limited to 25 characters in length.

The colors are:

- 1 - green
- 2 - cyan (bright blue)
- 3 - red
- 4 - blue-green (used for the control-panel)
- 5 - dark blue
- 6 - gold
- 7 - light yellow
- 8 to 15 - dark grey to white used for the stars



I have provided a sample database of several objects to demonstrate the file. The gold objects are radio sources, green ones are pulsars, quasars are cyan, and yellow is the 1987 Supernova. Comet Bradfield, which was visible in late 1987 is plotted in the blue-green.

You may also add up to 12 lines of extra commentary to each object by the use of separate "comment" files. These will be displayed when you click on top of each object using the point-and-identify feature. Each of the files must be named "uoX.etxt," where the "X" is the serial number of the object. So for the above example, the comment file would be "uo2.etxt."



## OPERATIONAL TIPS

If you are running DISTANT SUNS with 1 meg of memory or more and without a hard-disk, I would recommend purchasing FACC from ASDG Inc. and running it in conjunction with my program. FACC will greatly speed up disk access, especially when using point-and-identify. Also DISTANT SUNS uses several overlays in order to cut the size of the program in RAM. Overlaying a program is the process of loading in pieces as they are needed, then purging them from memory when done. The telescope is one example, since it will not be used all of the time. FACC will make this process virtually instantaneous.

Some of you may move DISTANT SUNS over to a hard-disk. There is a slight chance that a file might be dropped in the process. If so, the program will probably bite it along the way. Should this happen, starting DISTANT SUNS from CLI might print out some internal diagnostic messages that could help identify the problem.



## TECHNICAL NOTES

DISTANT SUNS 3.0 was written in about 3 1/2 years worth of spare time from February 1986 to August 1989 using Manx Aztec-C.

The system was a standard Amiga 1000 with a 2 Meg Alegra memory expansion, Ronin 68020 board and 65 meg hard-drive.

Most of the equations used were derived from the book Practical Astronomy With Your Calculator, by Peter Duffett-Smith. Additional material was used from Astronomical Formulae for Calculators by Jean Meeus.

By now you may have noticed that images of the sun and moon come in only two different sizes. The smaller size is correct for an FOV of 30 degrees while the larger size is accurate for 15 degrees. Because of the limited sizes, visual studies of events such as solar eclipses, transits, etc., are necessarily going to have limited accuracy and utility. In other words, what might appear to be an eclipse with an FOV of 75 degrees might just be caused by oversized images interfering with each other. That is why 30 degree FOV is recommended for eclipses. Furthermore, any timings derived from DISTANT SUNS will be only approximate.

You may notice that when running the time at some high rate of speed, the moon will move in a rather erratic fashion. This comes as a result of precision errors in the computation. Aztec C permits the use of either single or double precision, but not both at the same time. Since double precision is much slower than the single variety, I chose the latter. The lunar calculations require the use of very large numbers, but also require precision to several digits beyond the decimal point. When it is limited, the position of the moon jumps in noticeably discrete steps. Also, the accuracy of planetary and stellar positions suffer the further you travel from the current date. Furthermore, I am using the Motorola Fast-Floating Point (FFP) math



libraries which likewise sacrifice precision for speed. I expect these problems to be corrected in the future with new compilers and libraries. But since my main concern was the authenticity of the display for current dates some of the more obscure astronomical behaviors would have to suffer until the supporting software catches up. I know that this will upset some astrophysics grad students out there, but if you want ultimate accuracy, use your department's VAX.

The calender used by DISTANT SUNS is the traditional Gregorian calender introduced by Pope Gregory XIII in 1582. The Julian calender, in use since 45 BC, had years which were slightly too long. As a result, dates had now slipped by a full 10 days from where they should have been. This error was eliminated by the weirdest October on record, when people went to bed on the 5th and woke up on the 15th. You will notice that DISTANT SUNS will not let you enter dates within this period. Also, there is no year "0," so the years go from 1 BC to 1 AD.

The stellar databases used in DISTANT SUNS, for all their glory, do have problems. When developing the program, I noticed that there were some very bright stars where none should be. I traced it down to some empty magnitude entries in the original database which the program interpreted as magnitude zero. No doubt there are similar problems waiting to be found, so if you find errors in the database don't hesitate to report them so they may be corrected in future versions.

I have been asked by many as to why I don't do doublebuffering for the screen scrolls (showing one image while building up another elsewhere in memory). In order to do this I would need to have a second full size star window to alternate with which would take up an additional 54K of memory. On a 512K machine, there just isn't enough space, although future versions may permit it if extra memory is available.



They say a program is never really tested until it hits the dealers' shelves. No doubt it is true in this case as in all others. I'm sure that there are bugs lurking in the recesses of some arcane structure just waiting to be released. Should you have the misfortune of discovering one of these please call Virtual Reality Laboratories. Inc. and report it. Before you do, see if it can be duplicated, and if so, carefully record all of the steps. This is essential if you should release one of the dreaded gurus from his electronic prison.

DISTANT SUNS doesn't send screen dumps directly to the printer because that requires making a snapshot in memory to avoid tying up the machine. This snapshot would require 64K of memory which just isn't available on the basic machines. Also, dumping it to an IFF file means that you can load it in to your favorite paint program and add any notes or diagrams to the image, as well as optimizing the colors for your printer.

Many have asked why I don't do stars or deep-sky objects in the telescope. With stars I would have to have a much larger database to draw from, since a simple (real) telescope would reveal literally millions of stars. The storage on disk and in memory would be far too prohibitive. With deep-sky objects, I would be required to store potentially dozens of images in chip RAM at once to be able to give the user instant access to any image within the telescope's region. Considering the fact that each image could easily take from 1K to 3K of memory, you can see that you would run out of space in short order. (Not to mention the time it would take to load them into memory).



## APPENDIX A MESSIER CATALOGUE

| MESS | NGC    | CON | TYPE  | R.A.   | DECL  | MAG | DIST(1) | COMMENTS               |
|------|--------|-----|-------|--------|-------|-----|---------|------------------------|
| M 1  | 1952   | Tau | PlNeb | 0531.5 | +2159 | 8.2 | 6K      | Crab Nebula            |
| M 2  | 7089   | Aqr | GlbCl | 2130.9 | -0103 | 6.3 | 50K     |                        |
| M 3  | 5272   | CVn | GlbCl | 1339.9 | +2838 | 6.3 | 30K     |                        |
| M 4  | 6121   | Sco | GlbCl | 1620.6 | -2624 | 6.4 | 10K     |                        |
| M 5  | 5904   | Ser | GlbCl | 1516.0 | +0216 | 6.2 | 30K     |                        |
| M 6  | 6405   | Sco | OpCl  | 1736.8 | -3211 | 5.3 | 2K      |                        |
| M 7  | 6475   | Sco | OpCl  | 1750.7 | -3448 | 4.1 | 1K      |                        |
| M 8  | 6523   | Sgr | DfNeb | 1801.6 | -2420 | 6.0 | 6.5K    | Lagoon Nebula          |
| M 9  | 6333   | Oph | GlbCl | 1716.2 | -1828 | 7.3 | 25K     |                        |
| M 10 | 6254   | Oph | GlbCl | 1654.5 | -0402 | 6.7 | 16K     |                        |
| M 11 | 6705   | Sct | OpCl  | 1848.4 | -0620 | 6.3 | 6K      |                        |
| M 12 | 6218   | Oph | GlbCl | 1644.6 | -0152 | 6.6 | 16K     |                        |
| M 13 | 6205   | Her | GlbCl | 1639.9 | +3633 | 5.7 | 25K     |                        |
| M 14 | 6402   | Oph | GlbCl | 1735.0 | -0313 | 7.7 | 23K     |                        |
| M 15 | 7078   | Peg | GlbCl | 2127.6 | +1157 | 6.0 | 40K     |                        |
| M 16 | 6611   | Ser | OpCl  | 1816.0 | -1348 | 6.4 | 7K      | nebula & cluster       |
| M 17 | 6618   | Sgr | DfNeb | 1818.0 | -1612 | 7.5 | 5K      | Omega Nebula & cluster |
| M 18 | 6613   | Sgr | OpCl  | 1817.0 | -1709 | 7.5 | 6K      |                        |
| M 19 | 6273   | Oph | GlbCl | 1659.5 | -2611 | 6.6 | 20K     |                        |
| M 20 | 6514   | Sgr | DfNeb | 1758.9 | -2302 | 9.0 | 2.2K    | Trifid Nebula          |
| M 21 | 6531   | Sgr | OpCl  | 1801.8 | -2230 | 6.5 | 3K      |                        |
| M 22 | 6656   | Sgr | GlbCl | 1833.3 | -2358 | 5.9 | 10K     |                        |
| M 23 | 6494   | Sgr | OpCl  | 1754.0 | -1901 | 6.9 | 4.5K    |                        |
| M 24 | 6603   | Sgr | OpCl  | 1815.5 | -1827 | 4.6 | 10K     | star cloud             |
| M 25 | IC4725 | Sgr | OpCl  | 1828.8 | -1917 | 6.5 | 2K      | open cloud             |
| M 26 | 6694   | Sct | OpCl  | 1842.5 | -0927 | 9.3 | 5K      |                        |
| M 27 | 6853   | Vul | PlNeb | 1957.4 | +2235 | 7.6 | 1250    | Dumbbell Nebula        |
| M 28 | 6626   | Sgr | GlbCl | 1821.5 | -2454 | 7.3 | 15K     |                        |
| M 29 | 6913   | Cyg | OpCl  | 2022.2 | +3821 | 7.1 | 7.2K    |                        |
| M 30 | 7099   | Cap | GlbCl | 2137.5 | -2325 | 8.4 | 40K     |                        |
| M 31 | 224    | And | SpGal | 0040.0 | +4100 | 4.8 | 2,200K  | Andromeda Galaxy       |
| M 32 | 221    | And | ElGal | 0040.0 | +4036 | 8.7 | 2,200K  | satellite of M31       |
| M 33 | 598    | Tri | SpGal | 0131.1 | +3024 | 6.7 | 2,300K  | Sc                     |
| M 34 | 1039   | Per | OpCl  | 0238.8 | +4234 | 5.5 | 1,400   |                        |
| M 35 | 2168   | Gem | OpCl  | 0605.7 | +2420 | 5.3 | 2,800   |                        |
| M 36 | 1960   | Aur | OpCl  | 0532.0 | +3407 | 6.3 | 4,100   |                        |
| M 37 | 2099   | Aur | OpCl  | 0549.0 | +3233 | 6.2 | 4,600   |                        |
| M 38 | 1912   | Aur | OpCl  | 0525.3 | +3548 | 7.4 | 4,200   |                        |
| M 39 | 7092   | Cyg | OpCl  | 2130.4 | +4813 | 5.2 | 900     |                        |
| M 40 | WNC4   | UMa | DS    | 1220.0 | +5822 | 9.1 |         | double star            |
| M 41 | 2287   | CMa | OpCl  | 0644.9 | -2042 | 4.6 | 2,400   |                        |
| M 42 | 1976   | Ori | DfNeb | 0532.9 | -0525 | 4.0 | 1 K     | Great Orion Nebula     |



| MESS | NGC  | CON | TYPE  | R.A.   | DECL  | MAG  | DIST(1) | COMMENTS                 |
|------|------|-----|-------|--------|-------|------|---------|--------------------------|
| M 43 | 1982 | Ori | DfNeb | 0533.1 | -0518 | 9.1  | 1K      | part of Great Orion Neb. |
| M 44 | 2632 | Cnc | OpCI  | 0837.5 | +1952 | 3.7  | 500     | Praesepe                 |
| M 45 |      | Tau | OpCI  | 0343.9 | +2358 | 1.6  | 400     | The Pleiades             |
| M 46 | 2437 | Pup | OpCI  | 0739.6 | -1442 | 6.0  | 5,400   |                          |
| M 47 | 2422 | Pup | OpCI  | 0734.3 | -1422 | 4.5  | 1,600   |                          |
| M 48 | 2548 | Hya | OpCI  | 0811.2 | -0538 | 5.3  | 1,500   |                          |
| M 49 | 4472 | Vir | ElGal | 1227.3 | +0816 | 8.5  | 70000K  |                          |
| M 50 | 2323 | Mon | OpCI  | 0700.5 | -0816 | 6.3  | 3K      |                          |
| M 51 | 5194 | CVn | SpGal | 1327.8 | +4727 | 8.1  | 15000K  | Whirlpool Galaxy         |
| M 52 | 7654 | Cas | OpCI  | 2322.0 | +6120 | 7.3  | 7K      |                          |
| M 53 | 5024 | Com | GlbCI | 1310.5 | +1826 | 7.6  | 60K     |                          |
| M 54 | 6715 | Sgr | GlbCI | 1852.0 | -3032 | 8.0  | 50K     |                          |
| M 55 | 6809 | Sgr | GlbCI | 1936.9 | -3103 | 5.0  | 20K     |                          |
| M 56 | 6779 | Lyr | GlbCI | 1914.6 | +3005 | 8.2  | 40K     |                          |
| M 57 | 6720 | Lyr | PlNeb | 1851.7 | +3258 | 9.3  | 4,100   | Ring Nebula              |
| M 58 | 4579 | Vir | SpGal | 1235.1 | +1205 | 9.2  | 70000K  | Sb-barred spiral galaxy  |
| M 59 | 4621 | Vir | ElGal | 1239.5 | +1155 | 9.6  | 70000K  |                          |
| M 60 | 4649 | Vir | ElGal | 1241.1 | +1149 | 8.9  | 70000K  |                          |
| M 61 | 4303 | Vir | SpGal | 1219.4 | +0445 | 10.1 | 70000K  | Sc-barred spiral galaxy  |
| M 62 | 6266 | Oph | GlbCI | 1658.1 | -3003 | 6.6  | 26K     |                          |
| M 63 | 5055 | CVn | SpGal | 1313.5 | +4217 | 9.5  | 14500K  | Sb                       |
| M 64 | 4826 | Com | SpGal | 1254.3 | +2157 | 8.8  | 12000K  | Sb                       |
| M 65 | 3623 | Leo | SpGal | 1116.3 | +1323 | 9.3  | 35000K  | Sa                       |
| M 66 | 3627 | Leo | SpGal | 1117.6 | +1317 | 8.2  | 35000K  | Sb                       |
| M 67 | 2682 | Cnc | OpCI  | 0848.3 | +1200 | 6.1  | 2,250   | Alternate decl: 0847.8   |
| M 68 | 4590 | Hya | GlbCI | 1236.8 | -2629 | 8.0  | 40K     |                          |
| M 69 | 6637 | Sgr | GlbCI | 1828.1 | -3223 | 8.9  | 25K     |                          |
| M 70 | 6681 | Sgr | GlbCI | 1840.0 | -3221 | 9.6  | 65K     |                          |
| M 71 | 6838 | Sge | GlbCI | 1951.4 | +1839 | 9.0  | 8,500   |                          |
| M 72 | 6981 | Aqr | GlbCI | 2050.7 | -1244 | 9.8  | 60K     |                          |
| M 73 | 6994 | Aqr | OpCI  | 2056.4 | -1250 | 9.0  |         | cluster of 4 stars       |
| M 74 | 628  | Psc | SpGal | 0134.0 | +1532 | 10.2 | 20000K  | Sc                       |
| M 75 | 6864 | Sgr | GlbCI | 2003.2 | -2204 | 8.0  | 100K    |                          |
| M 76 | 650  | Per | PlNeb | 0138.8 | +5119 | 10.2 | 3,400   |                          |
| M 77 | 1068 | Cet | SpGal | 0240.1 | -0014 | 8.9  | 30000K  | Sb-Seyfert galaxy        |
| M 78 | 2068 | Ori | DfNeb | 0544.2 | +0002 | 10.3 | 1,600   | emission nebula          |
| M 79 | 1904 | Lep | GlbCI | 0522.2 | -2434 | 8.4  | 54K     |                          |
| M 80 | 6093 | Sco | GlbCI | 1614.1 | -2252 | 7.7  | 36K     |                          |
| M 81 | 3031 | UMa | SpGal | 0951.5 | +6918 | 7.9  | 7000K   | Sb                       |
| M 82 | 3034 | UMa | IrGal | 0951.9 | +6956 | 8.8  | 7000K   |                          |
| M 82 | 6341 | Her | GlbCI | 1715.6 | +4312 | 6.1  | 28K     |                          |
| M 83 | 5236 | Hya | SpGal | 1334.3 | -2937 | 10.1 | 8000K   | Sc                       |
| M 84 | 4374 | Vir | ElGal | 1222.6 | +1310 | 9.3  | 70000K  |                          |
| M 85 | 4382 | Com | ElGal | 1222.8 | +1828 | 9.3  | 70000K  | SO                       |
| M 86 | 4406 | Vir | ElGal | 1223.7 | +1313 | 9.7  | 70000K  | giant elliptical galaxy  |



| MESS | NGC  | CON | TYPE  | R.A.   | DECL  | MAG  | DIST(1) | COMMENTS                |
|------|------|-----|-------|--------|-------|------|---------|-------------------------|
| M87  | 4486 | Vir | ElGal | 1228.3 | +1240 | 9.2  | 70000K  | giant elliptical galaxy |
| M88  | 4501 | Com | SpGal | 1229.5 | +1442 | 10.2 | 40000K  | Sb                      |
| M89  | 4552 | Vir | ElGal | 1233.1 | +1250 | 9.5  | 70000K  |                         |
| M90  | 4569 | Vir | SpGal | 1234.3 | +1326 | 10.0 | 70000K  | Sb                      |
| M91  | 4548 | Com | SpGal | 1232.9 | +1446 | 9.5  | 40000K  | barred spiral galaxy    |
| M93  | 2447 | Pup | OpC1  | 0742.4 | -2345 | 6.0  | 36K     |                         |
| M94  | 4736 | CVn | SpGal | 1248.6 | +4123 | 7.9  | 14500K  | Sb                      |
| M95  | 3351 | Leo | SpGal | 1041.3 | +1158 | 10.4 | 25000K  | barred spiral galaxy    |
| M96  | 3368 | Leo | SpGal | 1044.2 | +1205 | 9.1  | 25000K  | Sa                      |
| M97  | 3587 | UMa | PlNeb | 112.0  | +5518 | 12.0 | 2,600   | Owl Nebula              |
| M98  | 4192 | Com | SpGal | 1211.3 | +1511 | 11.7 | 70000K  | Sb                      |
| M99  | 4254 | Com | SpGal | 1216.3 | +1442 | 10.1 | 70000K  | Sc                      |
| M100 | 4321 | Com | SpGal | 1220.4 | +1606 | 10.6 | 70000K  | Sc                      |
| M101 | 5457 | UMa | SpGal | 1401.4 | +5435 | 9.6  | 15000K  | Sc-same as M102         |
| M102 | 5457 | UMa | SpGal | 1401.4 | +5435 | 9.6  | 15000K  | Sc-same as M101         |
| M103 | 581  | Cas | OpC1  | 0129.9 | +6027 | 7.4  | 8K      |                         |
| M104 | 4594 | Vir | SpGal | 1237.3 | -1121 | 8.7  | 50000K  | Sombrero Galaxy         |
| M105 | 3379 | Leo | ElGal | 1045.2 | +1251 | 9.2  | 25000K  |                         |
| M106 | 4258 | CVn | SpGal | 1216.5 | +4735 | 8.6  | 25000K  | Sb                      |
| M107 | 6171 | Oph | GlbC1 | 1629.7 | -1257 | 9.2  | 10K     |                         |
| M108 | 3556 | UMa | SpGal | 1108.7 | +5557 | 10.7 | 25000K  | Sb                      |
| M109 | 3992 | UMa | SpGal | 1155.0 | +5339 | 10.8 | 25000K  | barred spiral galxy     |
| M110 | 205  | And | ElGal | 0037.6 | +4125 | 9.4  | 2200K   | satellite of M31        |

(1) Distance is measured in light years



## APPENDIX B SUPPLIED NGC CATALOG

| NGC  | CON | CONST  | R.A.   | DECL  | MAG <sub>v</sub> | REMARKS                  |
|------|-----|--------|--------|-------|------------------|--------------------------|
| 40   | Cas | PI Neb | 0010.2 | +7215 | 10.2             | central star mag:11.4    |
| 55   | Scl | SpGal  | 0012.5 | -3930 |                  |                          |
| 104  | Tuc | GlbCI  | 0021.9 | -7221 | 4.5              |                          |
| 129  | Cas | OpCI   | 0027.6 | +5957 | 10.0             | number:50                |
| 133  | Cas | OpCI   | 0028.4 | +6304 | 9.1              | number:50                |
| 134  | Scl | SpGal  | 0027.9 | -3332 |                  |                          |
| 157  | Cet | SpGal  | 0032.3 | -0840 | 11.2             |                          |
| 185  | Cas | ElGal  | 0036.1 | +4804 | 11.7             |                          |
| 188  | Cep | OpCI   | 0039.4 | +8503 | 9.3              | number:70                |
| 205  | And | ElGal  | 0037.6 | +4125 | 9.4              |                          |
| 225  | Cas | OpCI   | 0040.5 | +6131 | 9.1              | number:20                |
| 246  | Cet | PI Neb | 0044.6 | -1209 | 8.5              | central star mag:11.3    |
| 247  | Cet | SpGal  | 0044.6 | -2101 |                  |                          |
| 253  | Scl | SpGal  | 0045.1 | -2534 | 8.9              |                          |
| 278  | Cas | ElGal  | 0049.2 | +4718 | 11.3             |                          |
| 281  | Cas | DfNeb  | 0050.4 | +5919 | 8.6              | spectrum:05e             |
| 288  | Scl | GlbCI  | 0050.2 | -2652 |                  |                          |
| 300  | Scl | SpGal  | 0052.6 | -3758 |                  |                          |
| 404  | And | ElGal  | 0106.6 | +3527 | 10.7             |                          |
| 457  | Cas | OpCI   | 0115.9 | +5804 | 7.5              | number:100               |
| 488  | Psc | SpGal  | 0119.1 | +0500 | 11.1             |                          |
| 524  | Psc | ElGal  | 0122.1 | +0916 | 11.1             |                          |
| 584  | Cet | ElGal  | 0128.8 | -0707 | 10.8             |                          |
| 596  | Cet | ElGal  | 0130.3 | -0717 | 11.5             |                          |
| 613  | Scl | SpGal  | 0132.0 | -2940 | 10.2             |                          |
| 659  | Cas | OpCI   | 0140.8 | +6028 | 9.8              | number:30                |
| 663  | Cas | OpCI   | 0142.6 | +6101 | 7.1              | number:80                |
| 720  | Cet | ElGal  | 0150.6 | +1359 | 10.5             |                          |
| 752  | And | OpCI   | 0154.7 | +3725 | 7.0              | number:70                |
| 772  | Ari | SpGal  | 0156.6 | +1846 | 10.9             |                          |
| 779  | Cet | SpGal  | 0157.2 | -0612 | 11.3             |                          |
| 821  | Ari | ElGal  | 0205.6 | +1046 | 11.2             |                          |
| 869  | Per | OpCI   | 0215.5 | +5655 | 4.4              | number:350-half dbl clus |
| 884  | Per | OpCI   | 0218.9 | +5653 | 4.7              | number:300-half dbl clus |
| 925  | Tri | SpGal  | 0224.3 | +3322 |                  |                          |
| 936  | Cet | SpGal  | 0225.1 | -0122 | 10.7             |                          |
| 1022 | Cet | SpGal  | 0236.1 | -0653 | 11.2             |                          |
| 1023 | Per | ElGal  | 0237.2 | +3852 |                  |                          |
| 1052 | Cet | ElGal  | 0238.6 | -0828 | 11.2             |                          |
| 1084 | En  | SpGal  | 0243.5 | -0747 | 11.0             |                          |
| 1097 | For | SpGal  | 0244.3 | -3029 |                  |                          |



| NGC  | CON | CONST | R.A.   | DECL  | MAGv | REMARKS                  |
|------|-----|-------|--------|-------|------|--------------------------|
| 1232 | Eri | SpGal | 0307.5 | -2046 |      |                          |
| 1245 | Per | OpC1  | 0311.2 | +4703 | 6.9  | number:40                |
| 1261 | Hor | GlbC1 | 0310.9 | -552S |      |                          |
| 1316 | For | SpGal | 0320.7 | -372S |      |                          |
| 1332 | Eri | ElGal | 0324.1 | -2131 | 10.4 |                          |
| 1342 | Per | OpC1  | 0328.4 | +3709 | 7.1  | number:40                |
| 136S | For | SpGal | 0331.8 | -3618 |      |                          |
| 1395 | Eri | ElGal | 0336.3 | -2311 |      |                          |
| 1398 | For | SpGal | 0336.8 | -2630 |      |                          |
| 1399 | For | ElGal | 0336.6 | -3537 |      |                          |
| 1407 | Eri | ElGal | 0337.9 | -1844 | 10.6 |                          |
| 1499 | Pcr | DfNeb | 0400.1 | +3617 | 4.1  | California               |
| 1501 | Cam | PlNeb | 0402.6 | +6047 | 13.3 | central star mag:13.4    |
| 1502 | Cam | OpC1  | 0403.0 | +6211 | 5.3  | number:15                |
| 1S14 | Tau | PlNeb | 0406.1 | +3038 | 10.8 | central star mag:9.7     |
| 1S28 | Per | OpC1  | 0411.4 | +5107 | 6.2  | number:80                |
| 1S32 | Eri | SpGal | 0410.2 | -3300 |      | edge-on barred spiral    |
| 1535 | Eri | PlNcb | 0412.1 | -1252 | 9.3  | central star mag:11.8    |
| 1545 | Per | OpC1  | 0417.1 | +5008 | 8.0  | number:25                |
| 1554 | Tau | DfNeb | 0419.9 | +1925 |      | spectrum:Gpe/Hind's Var. |
| 1647 | Tau | OpC1  | 0443.2 | +1859 | 6.3  | number:30                |
| 1664 | Aur | OpC1  | 0447.4 | +4337 | 7.5  | number:40                |
| 1700 | Eri | ElGal | 0454.4 | -0456 | 11.9 |                          |
| 1746 | Tau | OpC1  | 0500.6 | +2344 | 6.0  | number:60                |
| 1792 | Col | SpGal | 0503.5 | -3804 |      |                          |
| 1817 | Tau | OpC1  | 0509.2 | +1638 | 7.9  | number:10                |
| 1851 | Col | GlbC1 | 0512.4 | -4005 | 8.1  |                          |
| 1857 | Aur | OpC1  | 0516.6 | +3918 | 8.6  | number:45                |
| 1893 | Aur | OpC1  | 0522.4 | +3321 | 8.0  | number:20                |
| 1907 | Aur | OpC1  | 0524.7 | +3517 | 9.9  | number:40                |
| 1977 | Ori | DfNeb | 0533.0 | -0454 | 4.6  |                          |
| 1990 | Ori | DfNeb | 0533.7 | -0114 | 1.8  | spectrum:BOe             |
| 2023 | Ori | DfNeb | 0539.2 | -0215 | 7.9  | spectrum:B2              |
| 2024 | Ori | DfNeb | 0539.4 | -0152 | 1.9  | spectrum:BOne            |
| 2064 | Ori | DfNeb | 0543.8 | -0002 | 9.9  |                          |
| 2112 | Ori | OpC1  | 0551.3 | +0023 | 8.6  | number:90                |
| 2141 | Ori | OpC1  | 0600.3 | +1026 | 10.8 | number:100               |
| 2158 | Gem | OpC1  | 0604.3 | +2406 | 12.5 | number:40                |
| 2169 | Ori | OpC1  | 0605.7 | +1358 | 6.4  | number:18                |
| 2174 | Ori | DfNeb | 0606.7 | +2031 | 7.4  | spectrum:O6e             |
| 2175 | Ori | OpC1  | 0606.8 | +2020 | 6.7  | number:15                |
| 2194 | Ori | OpC1  | 0611.0 | +1250 | 9.2  | number:100               |
| 2215 | Mon | OpC1  | 0618.4 | -0716 | 8.6  | number:20                |
| 2237 | Mon | DfNeb | 0629.6 | +0440 |      | Rosetta                  |
| 2244 | Mon | OpC1  | 0629.7 | +0454 | 6.2  | number:16                |



| NGC  | CON | CONST | R.A.   | DECL  | MAGv | REMARKS                      |
|------|-----|-------|--------|-------|------|------------------------------|
| 2261 | Mon | DfNeb | 0636.4 | +0846 | 8.0  | spectrum:Bp/ Hubble's Var    |
| 2264 | Mon | OpC1  | 0638.4 | +0956 | 4.7  | number:20                    |
| 2264 | Mon | DfNeb | 0638.2 | +0957 | 4.7  | spectr:07n-Cone Nebula       |
| 2266 | Gem | OpC1  | 0640.5 | +2702 | 9.8  | number:30                    |
| 2281 | Aur | OpC1  | 0645.8 | +4107 | 6.7  | number:30                    |
| 2286 | Mon | OpC1  | 0645.1 | -0307 | 8.0  | number:50                    |
| 2298 | Pup | GlbC1 | 0647.2 | -3557 | 10.5 |                              |
| 2301 | Mon | OpC1  | 0649.2 | +0031 | 5.8  | number:60                    |
| 2324 | Mon | OpC1  | 0700.4 | +0108 | 8.8  | number:30                    |
| 2335 | Mon | OpC1  | 0704.2 | -1000 | 9.1  | number:35                    |
| 2353 | Mon | OpC1  | 0712.3 | -1012 | 5.3  | number:25                    |
| 2354 | CMa | OpC1  | 0712.2 | -2538 | 8.9  | number:60                    |
| 2360 | CMa | OpC1  | 0715.4 | -1533 | 9.5  | number:50                    |
| 2371 | Gem | PlNeb | 0722.4 | +2935 | 13.0 | central star mag:13.3        |
| 2392 | Gem | PlNeb | 0726.2 | +2101 | 8.3  | central star mag:10.5 Eskimo |
| 2395 | Gem | OpC1  | 0724.3 | +1341 | 9.4  |                              |
| 2403 | Cam | SpGal | 0732.0 | +6543 | 8.9  |                              |
| 2419 | Lyn | GlbC1 | 0734.8 | +3900 | 11.5 |                              |
| 2420 | Gem | OpC1  | 0735.4 | +2141 | 10.2 | number:20                    |
| 2421 | Pup | OpC1  | 0734.1 | -2030 | 9.4  | number:50                    |
| 2422 | Pup | OpC1  | 0734.3 | -1422 | 4.5  | number:50                    |
| 2423 | Pup | OpC1  | 0734.8 | -1345 | 6.9  | number:60                    |
| 2438 | Pup | PlNeb | 0739.6 | -1436 | 11.3 | central star mag:16.8        |
| 2439 | Pup | OpC1  | 0738.9 | -3132 | 7.1  | number:50                    |
| 2451 | Pup | OpC1  | 0743.6 | -3751 | 3.6  | number:50                    |
| 2477 | Pup | OpC1  | 0750.5 | -3825 | 5.7  | number:300                   |
| 2482 | Pup | OpC1  | 0752.8 | -2410 | 8.7  | number:50                    |
| 2489 | Pup | OpC1  | 0756.2 | -2956 | 9.4  | number:30                    |
| 2506 | Mon | OpC1  | 0757.7 | -1029 | 11.5 | number:50                    |
| 2509 | Pup | OpC1  | 0758.5 | -1856 | 9.3  | number:40                    |
| 2516 | Car | OpC1  | 0759.7 | -6044 | 3.0  | number:80                    |
| 2539 | Pup | OpC1  | 0808.4 | -1241 | 8.2  | number:150                   |
| 2547 | Vel | OpC1  | 0808.9 | -4907 | 5.1  | number:50                    |
| 2548 | Hya | OpC1  | 0811.2 | -0538 | 5.3  | number:80                    |
| 2567 | Pup | OpC1  | 0816.6 | -3029 | 8.3  | number:50                    |
| 2571 | Pup | OpC1  | 0816.9 | -2935 | 7.5  | number:25                    |
| 2587 | Pup | OpC1  | 0821.3 | -2920 | 9.1  | number:30                    |
| 2610 | Hya | PlNeb | 0831.2 | -1558 | 13.6 | central star mag:15.7        |
| 2627 | Pyx | OpC1  | 0835.2 | -2946 | 8.3  | number:40                    |
| 2655 | Cam | SpGal | 0849.4 | +7825 | 10.7 |                              |
| 2658 | Pyx | OpC1  | 0841.4 | -3229 | 9.2  | number:30                    |
| 2681 | Lyn | SpGal | 0850.0 | +5131 | 10.4 |                              |
| 2683 | Lyn | SpGal | 0849.6 | +3338 | 9.6  |                              |
| 2742 | UMa | SpGal | 0903.7 | +6041 | 11.2 |                              |
| 2768 | UMa | ElGal | 0907.8 | +6016 | 10.5 |                              |



| NGC  | CON | CONST | R.A.   | DECL  | MAG <sub>v</sub> | REMARKS                       |
|------|-----|-------|--------|-------|------------------|-------------------------------|
| 2775 | Cnc | SpGal | 0907.7 | +0715 | 10.7             |                               |
| 2787 | UMa | SpGal | 0914.9 | +6925 | 10.9             |                               |
| 2841 | UMa | SpGal | 0918.6 | +5112 | 9.3              |                               |
| 2859 | LMi | SpGal | 0921.3 | +3344 | 10.7             |                               |
| 2903 | Leo | SpGal | 0929.3 | +2144 | 9.1              |                               |
| 2950 | UMa | SpGal | 0939.1 | +5905 | 10.9             |                               |
| 2964 | Leo | SpGal | 0940.0 | +3205 | 11.0             |                               |
| 2976 | UMa | SpGal | 0943.2 | +6808 | 11.4             |                               |
| 2985 | UMa | SpGal | 0946.0 | +7231 | 10.6             |                               |
| 2997 | Ant | SpGal | 0943.5 | -3059 |                  |                               |
| 3003 | LMi | SpGal | 0945.6 | +3339 | 12.7             | edge-on                       |
| 3021 | LMi | SpGal | 0948.0 | +3347 | 11.7             |                               |
| 3077 | UMa | ElGal | 0959.4 | +6858 | 10.9             |                               |
| 3079 | UMa | SpGal | 0958.6 | +5557 | 11.2             |                               |
| 3115 | Sex | ElGal | 1002.8 | -0728 | 9.3              | Spindle Nebula                |
| 3132 | Vel | PlNeb | 1004.9 | -4011 | 8.2              | central starmag:10.6          |
| 3147 | Dra | SpGal | 1012.8 | +7339 | 10.9             |                               |
| 3184 | UMa | SpGal | 1015.2 | +4140 | 12.1             |                               |
| 3201 | Vel | GlbCl | 1015.5 | -4609 |                  |                               |
| 3242 | Hya | PlNeb | 1022.4 | -1823 | 9.0              | central starmag:11.4-Eye Neb. |
| 3310 | UMa | RGal  | 1035.7 | +5346 | 10.1             |                               |
| 3344 | LMi | SpGal | 1040.7 | +2511 | 10.4             |                               |
| 3372 | Car | DfNeb | 1043.1 | -5925 | 5.0              | spcctrum:Pec-Keyhole Neb      |
| 3377 | Leo | ElGal | 1045.1 | +1415 | 10.5             |                               |
| 3384 | Leo | ElGal | 1045.7 | +1254 | 10.2             |                               |
| 3412 | Leo | ElGal | 1048.3 | +1341 | 10.4             |                               |
| 3486 | LMi | SpGal | 1057.8 | +2915 | 11.2             |                               |
| 3504 | LMi | SpGal | 1100.5 | +2815 | 10.9             |                               |
| 3511 | Crt | SpGal | 1100.8 | +2250 |                  |                               |
| 3521 | Leo | SpGal | 1103.2 | +0014 | 9.5              |                               |
| 3585 | Hya | ElGal | 1110.9 | -2629 |                  |                               |
| 3607 | Leo | ElGal | 1114.3 | +1820 | 9.6              |                               |
| 3621 | Hya | SpGal | 1115.9 | -3232 |                  |                               |
| 3626 | Leo | SpGal | 1117.5 | +1838 | 10.5             |                               |
| 3628 | Leo | SpGal | 1117.7 | +1353 | 10.9             | edge-on                       |
| 3631 | UMa | SpGal | 1118.3 | +5328 | 11.2             |                               |
| 3646 | Leo | SpGal | 1119.2 | +2027 |                  |                               |
| 3675 | UMa | SpGal | 1123.5 | +4352 | 10.6             |                               |
| 3810 | Leo | SpGal | 1138.4 | +1145 | 10.8             |                               |
| 3877 | UMa | SpGal | 1143.5 | +4746 | 10.9             |                               |
| 3893 | UMa | SpGal | 1146.1 | +4900 | 11.3             |                               |
| 3923 | Hya | ElGal | 1148.5 | -2833 |                  |                               |
| 3941 | UMa | SpGal | 1150.3 | +3716 | 9.8              |                               |
| 3945 | UMa | SpGal | 1150.6 | +6057 | 10.8             |                               |
| 3949 | UMa | SpGal | 1151.1 | +4808 | 11.0             |                               |



| NGC  | CON | CONST | R.A.   | DECL  | MAG <sub>v</sub> | REMARKS               |
|------|-----|-------|--------|-------|------------------|-----------------------|
| 3953 | UMa | SpGal | 1151.2 | +5237 | 10.7             |                       |
| 3962 | Crt | ElGal | 1152.2 | -1342 | 11.3             |                       |
| 4026 | UMa | ElGal | 1156.9 | +5114 | 10.7             |                       |
| 4030 | Vir | SpGal | 1157.8 | -0049 | 11.0             |                       |
| 4036 | UMa | ElGal | 1158.9 | +6210 | 10.7             |                       |
| 4038 | Crv | SpGal | 1159.3 | -1835 |                  |                       |
| 4041 | UMa | SpGal | 1159.7 | +6225 | 11.0             |                       |
| 4051 | DMa | SpGal | 1200.6 | +4448 | 11.0             |                       |
| 4088 | UMa | SpGal | 1203.0 | +5049 | 10.9             |                       |
| 4105 | Hya | ElGal | 1204.1 | -2930 |                  |                       |
| 4111 | UMa | ElGal | 1204.5 | +4321 | 9.7              |                       |
| 4125 | Dra | ElGal | 1205.7 | +6527 | 10.2             |                       |
| 4143 | CVn | ElGal | 1207.1 | +4249 | 11.0             |                       |
| 4214 | CVn | IrGal | 1213.0 | +3636 | 10.3             |                       |
| 4216 | Vir | SpGal | 1213.4 | +1325 | 10.4             |                       |
| 4244 | CVn | SpGal | 1215.0 | +3805 | 11.9             |                       |
| 4251 | Com | SpGal | 1215.7 | +2827 | 10.2             |                       |
| 4261 | Vir | ElGal | 1216.8 | +0606 | 10.3             |                       |
| 4274 | Com | SpGal | 1217.4 | +2953 | 10.8             |                       |
| 4278 | Com | ElGal | 1217.7 | +2934 | 10.3             |                       |
| 4314 | Com | SpGal | 1220.0 | +3010 | 10.8             |                       |
| 4361 | Crv | PlNeb | 1221.9 | -1829 | 10.8             | central star mag:12.8 |
| 4365 | Vir | ElGal | 1222.0 | +0736 | 11.1             |                       |
| 4395 | CVn | SpGal | 1223.4 | +3349 |                  |                       |
| 4414 | Com | SpGal | 1224.0 | +3130 | 9.7              |                       |
| 4429 | Vir | SpGal | 1224.9 | +1123 | 11.2             |                       |
| 4438 | Vir | SpGal | 1225.3 | +1317 | 10.8             |                       |
| 4449 | CVn | IrGal | 1225.8 | +4422 | 9.2              |                       |
| 4450 | Com | SpGal | 1225.9 | +1721 | 10.0             |                       |
| 4459 | Com | ElGal | 1226.5 | +1514 | 10.9             |                       |
| 4465 | Vir | ElGal | 1225.2 | +1321 | 10.3             |                       |
| 4473 | Com | ElGal | 1227.3 | +1342 | 10.1             |                       |
| 4477 | Vir | SpGal | 1227.6 | +1355 | 10.7             |                       |
| 4490 | CVn | SpGal | 1228.3 | +4155 | 9.7              |                       |
| 4494 | Com | ElGal | 1228.9 | +2603 | 9.6              |                       |
| 4526 | Vir | ElGal | 1231.6 | +0758 | 10.9             |                       |
| 4535 | Vir | SpGal | 1231.8 | +0828 |                  |                       |
| 4536 | Vir | SpGal | 1231.9 | +0228 | 11.9             |                       |
| 4546 | Vir | ElGal | 1232.9 | -0331 | 10.0             |                       |
| 4565 | Com | SpGal | 1233.9 | +2616 | 10.2             | edge-on               |
| 4631 | CVn | SpGal | 1239.8 | +3249 | 9.3              | edge-on               |
| 4636 | Vir | ElGal | 1240.3 | +0257 | 10.4             |                       |
| 4643 | Vir | SpGal | 1240.8 | +0215 | 10.6             |                       |
| 4656 | CVn | SpGal | 1241.6 | +3226 | 11.2             |                       |
| 4660 | Vir | ElGal | 1242.0 | +1126 | 10.9             |                       |



| NGC  | CON | CONST | R.A.   | DECL  | MAG <sub>v</sub> | REMARKS               |
|------|-----|-------|--------|-------|------------------|-----------------------|
| 4666 | Vir | SpGal | 1242.6 | -0012 | 11.4             |                       |
| 4697 | Vir | ElGal | 1246.0 | -0532 | 9.6              |                       |
| 4699 | Vir | SpGal | 1246.5 | -0824 | 9.3              |                       |
| 4725 | Com | SpGal | 1248.1 | +2546 | 8.9              |                       |
| 4753 | Vir | SpGal | 1249.8 | -0055 | 10.8             |                       |
| 4754 | Vir | ElGal | 1249.7 | +1135 | 10.5             |                       |
| 4762 | Vir | SpGal | 1250.4 | +1131 | 11.0             |                       |
| 4775 | Vir | SpGal | 1251.1 | -0621 |                  |                       |
| 4781 | Vir | SpGal | 1251.8 | -1016 | 11.2             |                       |
| 4800 | CVn | SpGal | 1252.4 | +4648 | 11.1             |                       |
| 4826 | Vir | SpGal | 1254.3 | +2157 | 8.8              |                       |
| 4856 | Vir | ElGal | 1256.7 | -1446 |                  |                       |
| 4900 | Vir | SpGal | 1258.2 | +0246 | 11.3             |                       |
| 4945 | Cen | SpGal | 1302.4 | -4901 |                  |                       |
| 4958 | Vir | ElGal | 1303.1 | -0745 | 10.9             |                       |
| 4995 | Vir | SpGal | 1307.0 | -0734 | 11.2             |                       |
| 5005 | CVn | SpGal | 1308.5 | +3719 | 9.8              |                       |
| 5033 | CVn | SpGal | 1311.2 | +3651 | 10.3             |                       |
| 5044 | Vir | ElGal | 1312.8 | -1608 | 11.2             |                       |
| 5053 | Com | GlbCI | 1313.9 | +1757 |                  |                       |
| 5068 | Vir | SpGal | 1316.2 | -2047 |                  |                       |
| 5102 | Cen | ElGal | 1319.1 | -3623 |                  |                       |
| 5128 | Cen | IrGal | 1322.4 | -4245 | 7.2              | Centaurus-A           |
| 5139 | Cen | GlbCI | 1323.8 | -4703 | 3.7              | Omega Centauri        |
| 5195 | CVn | IrGal | 1327.9 | +4731 | 8.4              | Pec-companion to MS1  |
| 5248 | Boo | SpGal | 1335.1 | +0908 | 11.3             |                       |
| 5322 | UMa | ElGal | 1347.6 | +6026 | 10.0             |                       |
| 5363 | Vir | ElGal | 1353.6 | +0529 | 10.7             |                       |
| 5377 | CVn | SpGal | 1354.3 | +4727 | 11.2             |                       |
| 5427 | Vir | SpGal | 1400.8 | -0547 |                  |                       |
| 5466 | Boo | GlbCI | 1403.2 | +2846 | 8.5              |                       |
| 5566 | Vir | SpGal | 1417.8 | +0411 | 10.4             |                       |
| 5746 | Vir | SpGal | 1442.3 | +0210 | 10.1             |                       |
| 5775 | Vir | SpGal | 1451.5 | +0345 |                  |                       |
| 5824 | Lup | GlbCI | 1500.9 | -3253 | 10.1             |                       |
| 5846 | Vir | ElGal | 1504.0 | +0148 | 10.5             | EO                    |
| 5873 | Lup | PIneb | 1509.4 | -3754 | 9.7              |                       |
| 5897 | Lib | GlbCI | 1514.5 | -2050 | 10.9             |                       |
| 5982 | Dra | ElGal | 1537.6 | +5932 | 10.9             |                       |
| 5986 | Lup | GlbCI | 1542.8 | -3737 | 8.7              |                       |
| 6058 | Her | PIneb | 1602.8 | +4049 | 12.3             | central star mag:13.4 |
| 6139 | Sco | GlbCI | 1524.3 | -3844 |                  |                       |
| 6144 | Sco | GlbCI | 1624.2 | -2556 |                  |                       |
| 6210 | Oph | PIneb | 1642.5 | +2353 | 9.7              | central star mag:12.5 |
| 6268 | Sco | OpCI  | 1658.6 | -3939 | 9.5              | number:30             |



| NGC  | CON | CONST  | R.A.   | DECL  | MAG <sub>v</sub> | REMARKS               |
|------|-----|--------|--------|-------|------------------|-----------------------|
| 6281 | Sco | OpCl   | 1701.4 | -3749 | 8.6              | number:25             |
| 6284 | Oph | GlbCl  | 1701.5 | -2441 | 9.7              |                       |
| 6293 | Oph | GlbCl  | 1707.1 | -2630 | 8.4              |                       |
| 6304 | Oph | GlbCl  | 1711.4 | -2924 | 9.8              |                       |
| 6316 | Oph | GlbCl  | 1713.4 | -2805 |                  |                       |
| 6352 | Ara | GlbCl  | 1721.6 | -4826 |                  |                       |
| 6356 | Oph | GlbCl  | 1720.7 | -1746 | 8.7              |                       |
| 6369 | Oph | PlNeb  | 1726.3 | -2344 | 9.9              | central star mag:16.6 |
| 6383 | Sco | OpCl   | 1731.4 | -3233 | 5.5              | number r:12           |
| 6388 | Sco | GlbCl  | 1732.6 | 4443  |                  |                       |
| 6397 | Ara | GlbCl  | 1736.8 | -5339 |                  |                       |
| 6400 | Sco | OpCl   | 1736.1 | -3655 | 8.9              | number:25             |
| 6441 | Sco | C,lbCl | 1746.8 | -3702 |                  |                       |
| 6445 | Sgr | PlNeb  | 1746.3 | -2000 | 13.2             | central star mag:19.1 |
| 6503 | Dra | SpGal  | 1549.9 | +7010 | 9.6              |                       |
| 6528 | Sgr | GlbCl  | 1801.6 | -3004 |                  |                       |
| 6541 | CrA | GlbCl  | 1804.4 | -4344 |                  |                       |
| 6543 | Dra | PlNeb  | 1758.8 | +6638 | 8.8              | central star mag:11.1 |
| 6572 | Oph | PlNeb  | 1809.7 | +0650 | 9.6              | central star mag:12.0 |
| 6584 | Tel | GlbCl  | 1814.6 | -5214 |                  |                       |
| 6620 | Sgr | PlNeb  | 1818.7 | -2652 | 15.0             | central star mag:15.8 |
| 6624 | Sgr | GlbCl  | 1820.5 | -3023 |                  |                       |
| 6629 | Sgr | PlNeb  | 1822.7 | -2314 | 10.6             | central star mag:13.6 |
| 6638 | Sgr | GlbCl  | 1827.9 | -2532 | 9.8              |                       |
| 6652 | Sgr | GlbCl  | 1832.5 | -3302 |                  |                       |
| 6664 | Sct | OpCl   | 1734.0 | -0816 | 8.9              | number:25             |
| 6709 | Aql | OpCl   | 1749.1 | +1017 | 8.1              | number:40             |
| 6712 | Sct | GlbCl  | 1850.3 | -0847 | 8.9              |                       |
| 6723 | Sgr | GlbCl  | 1856.2 | -3642 |                  |                       |
| 6755 | Aql | OpCl   | 1905.3 | +0409 | 8.3              | number:50             |
| 6760 | Aql | GlbCl  | 1908.6 | +0057 | 10.7             |                       |
| 6790 | Aql | PlNeb  | 1920.4 | +0124 | 11.4             | central star mag:18.4 |
| 6803 | Aql | PlNeb  | 1928.9 | +0958 | 11.4             | central star mag:14.1 |
| 6811 | Cyg | OpCl   | 1936.7 | +4627 | 9.2              | number:50             |
| 6818 | Sgr | PlNeb  | 1941.1 | -1417 | 9.9              | central starmag:15.0  |
| 6819 | Cyg | OpCl   | 1939.6 | +4006 | 10.1             | number:150            |
| 6822 | Sgr | TrGal  | 1942.1 | -1453 | 10.0             |                       |
| 6826 | Cyg | PlNeb  | 1943.4 | +5024 | 8.8              | central starmag:10.8  |
| 6830 | Vul | OpCl   | 1948.9 | +2258 | 9.0              | number:20             |
| 6842 | Vul | PlNeb  | 1953.0 | +2909 | 13.6             | central star mag:14.1 |
| 6871 | Cyg | OpCl   | 2004.0 | +3538 | 5.6              | number:60             |
| 6879 | Sge | PlNeb  | 2008.1 | +1646 | 12.1             | central star mag:15.2 |
| 6885 | Vul | OpCl   | 2009.9 | +2620 | 9.1              | number:35             |
| 6886 | Sge | PlNeb  | 2010.5 | +1950 | 12.2             | central star mag:16.6 |
| 6891 | Aql | PlNeb  | 2012.8 | +1235 | 11.4             | central star mag:11.6 |



| NGC  | CON | CONST | R.A.   | DECL  | MAGv | REMARKS                        |
|------|-----|-------|--------|-------|------|--------------------------------|
| 6894 | Cyg | PlNeb | 2014.4 | +3025 | 14.4 | central star mag:17.0          |
| 6905 | Del | PlNeb | 2020.2 | +1957 | 11.9 | central star mag:14.2          |
| 6910 | Cyg | OpCl  | 2021.3 | +4037 | 6.7  | number:40                      |
| 6934 | Del | GlbCl | 2031.7 | +0714 | 9.2  |                                |
| 6939 | Cep | OpCl  | 2030.4 | +6028 | 10.0 | number:80                      |
| 6940 | Vul | OpCl  | 2032.5 | +2808 | 8.2  | number:100                     |
| 6946 | Cep | SpGal | 2033.9 | +5958 |      |                                |
| 6960 | Cyg | DfNeb | 2043.6 | +3032 | 8.0  | Cirrus, Veil Nebula            |
| 7000 | Cyg | DfNeb | 2057.0 | +4408 | 1.3  | spectrum:cA2e/ No. America     |
| 7006 | Del | GlbCl | 2059.1 | +1600 | 10.3 |                                |
| 7009 | Aqr | PlNeb | 2101.4 | -1134 | 8.4  | central star mag:12-Saturn Neb |
| 7023 | Cep | DfNeb | 2101.4 | +6758 | 7.2  | spectrum B5a                   |
| 7026 | Cyg | PlNeb | 2104.6 | +4739 | 12.7 | central star mag:14.8          |
| 7027 | Cyg | PlNeb | 2105.1 | +4202 | 10.4 | central star mag:17.1          |
| 7086 | Cyg | OpCl  | 2129.8 | +5122 | 9.4  | number:50                      |
| 7128 | Cyg | OpCl  | 2142.4 | +5329 | 11.2 | number:20                      |
| 7209 | Lac | OpCl  | 2201.8 | +4616 | 7.6  | number:50                      |
| 7217 | Peg | SpGal | 2205.6 | +3107 |      |                                |
| 7243 | Lac | OpCl  | 2213.2 | +4938 | 7.4  | number:40                      |
| 7293 | Aqr | PlNeb | 2227.0 | -2106 | 6.5  | central star mag:13-Helix Neb. |
| 7331 | Peg | SpGal | 2234.7 | +3410 | 9.7  |                                |
| 7448 | Peg | SpGal | 2257.6 | +1543 | 11.2 |                                |
| 7541 | Psc | SpGal | 2312.2 | +0415 | 12.1 |                                |
| 7635 | Cas | PlNeb | 2318.5 | +6054 | 8.5  | central star mag:8.5           |
| 7662 | And | PlNeb | 2323.5 | +4214 | 8.9  | central star mag:12.5          |
| 7723 | Aqr | SpGal | 2336.4 | -1314 | 11.1 |                                |
| 7727 | Aqr | SpGal | 2337.3 | -1234 | 10.7 |                                |
| 7789 | Cas | OpCl  | 2254.5 | +5626 | 9.6  | number:200                     |
| 7790 | Cas | OpCl  | 2254.5 | +6056 | 7.1  | number:25                      |
| 7793 | Scl | SpGal | 2355.3 | -3251 | 9.7  |                                |

OpCl = Open Cluster  
 GlbCl = Globular Cluster  
 PlNeb = Planetary Nebula  
 DfNeb = Diffuse Nebula  
 SpGal = Spiral Galaxy  
 ElGal = Elliptical Galaxy  
 IrGal = Irregular Galaxy



## APPENDIX C PLANETARY DATA

|         | Mean<br>distance<br>from<br>Sun in<br>millions<br>of miles | Period<br>revolution<br>around the<br>Sun | Inclination<br>to ecliptic<br>• |    | Diameter<br>(miles)<br>axis | Period of<br>rotation on<br>axis |
|---------|------------------------------------------------------------|-------------------------------------------|---------------------------------|----|-----------------------------|----------------------------------|
| Mercury | 36.0                                                       | 87d.9                                     | 7                               | 0  | 3,100                       | 58.66d                           |
| Venus   | 67.2                                                       | 224d.7                                    | 3                               | 24 | 7,700                       | 243.2d                           |
| Earth   | 93.0                                                       | 365d.2                                    | 0                               | 0  | 7,927                       | 23h56m                           |
| Mars    | 141.7                                                      | 1y.8                                      | 1                               | 51 | 4,200                       | 24h37m                           |
| Jupiter | 483.8                                                      | 11y.8                                     | 1                               | 18 | 88,700                      | 9h50m                            |
| Saturn  | 887.1                                                      | 29y.4                                     | 2                               | 29 | 75,100                      | 16h39m                           |
| Uranus  | 1783.9                                                     | 84y.0                                     | 0                               | 46 | 32,000                      | 12.8h                            |
| Neptune | 2795.4                                                     | 164y.7                                    | 1                               | 46 | 27,700                      | 15.8h                            |
| Pluto   | 3675.2                                                     | 248y.4                                    | 17                              | 9  | 1,500(?)                    | 6d8h(?)                          |

|         | Inclination<br>of equator<br>to orbit<br>plane | Surface<br>gravity<br>earth = 1 | Density<br>H <sub>2</sub> O-1 | Number<br>of<br>Satellites | Mean<br>velocity<br>in orbit<br>(mi/sec) | Max.<br>Stellar<br>mag. |
|---------|------------------------------------------------|---------------------------------|-------------------------------|----------------------------|------------------------------------------|-------------------------|
| Mercury | 7                                              | 0.28                            | 3.8                           | 0                          | 30                                       | -1.2                    |
| Venus   | --                                             | 0.85                            | 5.1                           | 0                          | 22                                       | -4.4                    |
| Earth   | 23.4                                           | 1.00                            | 5.5                           | 1                          | 18.5                                     | --                      |
| Mars    | 25.2                                           | 0.38                            | 4.0                           | 2                          | 15                                       | -2.8                    |
| Jupiter | 3.1                                            | 2.6                             | 1.3                           | 16                         | 8                                        | -2.5                    |
| Saturn  | 26.8                                           | 1.2                             | 0.7                           | 17                         | 6                                        | -0.4                    |
| Uranus  | 98                                             | 1.1                             | 1.3                           | 15                         | 4                                        | +5.7                    |
| Neptune | 29                                             | 1.4                             | 2.2                           | 2                          | 3                                        | +7.8                    |
| Pluto   | --                                             |                                 | >1.0                          | 1                          | <3                                       | +14                     |



## APPENDIX D

### MAJOR VISUAL METEOR SHOWS

| Shower               | Date    | Position at Max |    | De  | Single Observer Hourly Rate | Normal Duration to 1/4 Strength of Max. |
|----------------------|---------|-----------------|----|-----|-----------------------------|-----------------------------------------|
|                      |         | R.A.            |    |     |                             |                                         |
|                      |         | h               | m  |     |                             | days                                    |
| Quadrantids          | Jan. 4  | 15              | 28 | +50 | 40                          | 1.1                                     |
| Lyrids               | Apr. 22 | 18              | 16 | +34 | 15                          | 2.3                                     |
| $\pi$ Aquarids       | May 5   | 22              | 22 | -1  | 20                          | 3                                       |
| s. $\delta$ Aquarids | July 29 | 22              | 36 | -17 | 20                          | 7                                       |
| Perseids             | Aug. 12 | 03              | 04 | +58 | 50                          | 4.5                                     |
| Orionids             | Oct. 21 | 06              | 20 | +15 | 25                          | 2                                       |
| S. Taurids           | Nov. 3  | 03              | 32 | +14 | 15                          | —                                       |
| Leonids              | Nov. 18 | 10              | 08 | +22 | 15                          | —                                       |
| Geminids             | Dec. 14 | 07              | 32 | +32 | 50                          | 2.5                                     |
| Ursids               | Dec. 23 | 14              | 28 | +78 | 15                          | 2.2                                     |

\*Peak dates may vary +/-1 day from year to year. Call your local planetarium or University Astronomical Dept. for more timely information.



## APPENDIX E

### LOCATION/TIME ZONES OF MAJOR CITIES

| Name        | Latitude<br>Deg Min NS |    |   | Longitude<br>Deg Min EW |    |   | State,Country          | Time Zone |
|-------------|------------------------|----|---|-------------------------|----|---|------------------------|-----------|
| Accra       | 5                      | 33 | N | 0                       | 15 | W | Ghana, Africa          | 0         |
| Albuquerque | 35                     | 05 | N | 106                     | 38 | W | New Mexico, USA        | +7        |
| Anchorage   | 61                     | 10 | N | 149                     | 53 | W | Alaska, USA            | +10       |
| Amsterdam   | 52                     | 21 | N | 4                       | 54 | E | Netherlands, Europe    | -1        |
| Ankara      | 39                     | 55 | N | 32                      | 50 | E | Turkey, Asia Minor     | -2        |
| Asuncion    | 25                     | 15 | S | 57                      | 40 | W | Paraguay, S. Am.       | +4        |
| Athens      | 38                     | 00 | N | 23                      | 44 | E | Greece, Europe         | -2        |
| Atlanta     | 33                     | 45 | N | 84                      | 23 | W | Georgia, USA           | +5        |
| Baghdad     | 33                     | 20 | N | 44                      | 26 | E | Iraq, Middle East      | -3        |
| Baltimore   | 39                     | 17 | N | 76                      | 37 | W | Maryland, USA          | +5        |
| Bangkok     | 13                     | 44 | N | 100                     | 30 | E | Thailand, Asia         | -7        |
| Beirut      | 33                     | 52 | N | 35                      | 30 | E | Lebanon, Middle East 2 |           |
| Benghazi    | 32                     | 07 | N | 20                      | 05 | E | Libya, Africa          | -2        |
| Berlin      | 52                     | 32 | N | 13                      | 25 | E | W. Germany, Europe     | -1        |
| Bern        | 46                     | 57 | N | 7                       | 26 | E | Switzerland, Europe    | -1        |
| Bombay      | 18                     | 56 | N | 72                      | 51 | E | India, Asia            | -5.5      |
| Bonn        | 50                     | 44 | N | 7                       | 06 | E | W. Germany, Europe     | -1        |
| Boston      | 42                     | 20 | N | 71                      | 05 | W | Massachusetts, USA     | +5        |
| Brussels    | 50                     | 50 | N | 4                       | 21 | E | Belgium, Europe        | -1        |



| Name         | Latitude<br>Deg Min NS |    |   | Longitude<br>Deg Min EW |    |   | State,Country        | Time Zone |
|--------------|------------------------|----|---|-------------------------|----|---|----------------------|-----------|
| Bucharest    | 44                     | 25 | N | 26                      | 07 | E | Romania, Europe      | -2        |
| Buenos Aires | 34                     | 40 | S | 58                      | 30 | W | Argentina, S. Am.    | +3        |
| Cairo        | 30                     | 03 | N | 31                      | 15 | E | Egypt, Africa        | -2        |
| Calgary      | 51                     | 03 | N | 114                     | 05 | W | Alberta, Canada      | +7        |
| Cape Town    | 33                     | 56 | S | 18                      | 28 | E | South Africa, Africa | -2        |
| Caracas      | 10                     | 35 | N | 66                      | 56 | W | Venezuela, S. Am     | +4.5      |
| Casablanca   | 33                     | 39 | N | 7                       | 35 | W | Morocco, Africa      | 0         |
| Chicago      | 41                     | 59 | N | 87                      | 38 | W | Illinois, USA        | +6        |
| Cincinnati   | 39                     | 06 | N | 84                      | 31 | W | Ohio, USA            | +5        |
| Cleveland    | 41                     | 30 | N | 81                      | 41 | W | Ohio, USA            | +5        |
| Dakar        | 14                     | 38 | N | 17                      | 27 | W | Senegal, Africa      | 0         |
| Dallas       | 32                     | 47 | N | 96                      | 48 | W | Texas, USA           | +6        |
| Denver       | 39                     | 45 | N | 105                     | 00 | W | Colorado, USA        | +7        |
| Des Moines   | 45                     | 35 | N | 93                      | 35 | W | Iowa, USA            | +6        |
| Detroit      | 42                     | 20 | N | 83                      | 03 | W | Michigan, USA        | +5        |
| Dublin       | 53                     | 20 | N | 6                       | 15 | W | Ireland, Europe      | 0         |
| El Paso      | 31                     | 45 | N | 106                     | 29 | W | Texas, USA           | +7        |
| Fairbanks    | 64                     | 51 | N | 147                     | 43 | W | Alaska, USA          | +10       |
| Hanoi        | 21                     | 01 | N | 105                     | 52 | E | Vietnam, Asia        | -8        |
| Havana       | 23                     | 07 | N | 82                      | 25 | W | Cuba, Caribbean      | +5        |
| Helsinki     | 60                     | 08 | N | 25                      | 00 | E | Finland, Europe      | -2        |
| Hiroshima    | 34                     | 23 | N | 132                     | 27 | E | Japan, Asia          | -9        |



| Name         | Latitude<br>Deg Min NS |    |   | Longitude<br>Deg Min EW |    |   | State,Country        | Time Zone |
|--------------|------------------------|----|---|-------------------------|----|---|----------------------|-----------|
| Hong Kong    | 22                     | 15 | N | 114                     | 11 | E | Asia                 | -8        |
| Honolulu     | 21                     | 19 | N | 157                     | 52 | W | Hawaii, USA          | +10       |
| Houston      | 29                     | 46 | N | 95                      | 22 | W | Texas, USA           | +6        |
| Indianapolis | 39                     | 46 | N | 86                      | 09 | W | Indiana, USA         | +5        |
| Istanbul     | 41                     | 02 | N | 28                      | 57 | E | Turkey, Asia Minor   | -3        |
| Jerusalem    | 31                     | 47 | N | 35                      | 13 | E | Israel, Middle East  | -2        |
| Johannesburg | 26                     | 10 | N | 28                      | 02 | E | South Africa, Africa | -2        |
| Kabul        | 34                     | 30 | N | 69                      | 10 | E | Afghanistan, Asia    | -5        |
| Kansas City  | 39                     | 05 | N | 94                      | 37 | W | Kansas/Missouri, USA | +6        |
| Karachi      | 24                     | 51 | N | 67                      | 02 | E | Pakistan, Asia       | -5        |
| Kiev         | 50                     | 26 | N | 30                      | 31 | E | USSR, Europe         | -3        |
| Kyoto        | 35                     | 02 | N | 135                     | 45 | E | Japan, Asia          | -9        |
| Lagos        | 6                      | 27 | N | 3                       | 28 | E | Nigeria, Africa      | -1        |
| Las Vegas    | 36                     | 11 | N | 115                     | 08 | W | Nevada, USA          | +8        |
| Leningrad    | 59                     | 55 | N | 30                      | 25 | E | USSR, Europe         | -3        |
| Lima         | 12                     | 06 | S | 77                      | 03 | W | Peru, S. America     | +5        |
| Lisbon       | 38                     | 44 | N | 9                       | 08 | W | Portugal, Europe     | 0         |
| London       | 51                     | 30 | N | 0                       | 10 | W | England, Europe      | 0         |
| Los Angeles  | 34                     | 00 | N | 118                     | 15 | W | California, USA      | +8        |
| Madrid       | 40                     | 25 | N | 3                       | 43 | W | Spain, Europe        | -1        |
| Manila       | 14                     | 37 | N | 120                     | 58 | E | Phillipines          | -8        |
| Marrakech    | 31                     | 49 | N | 8                       | 00 | W | Morocco, Africa      | 0         |



| Name          | Latitude<br>Deg Min NS |    |   | Longitude<br>Deg Min EW |    |   | State,Country        | Time Zone |
|---------------|------------------------|----|---|-------------------------|----|---|----------------------|-----------|
| Mecca         | 21                     | 26 | N | 39                      | 49 | E | Saudi Arabia, M.East | -3        |
| Melbourne     | 37                     | 45 | S | 144                     | 58 | E | Victoria, Australia  | -10       |
| Mexico City   | 19                     | 25 | N | 99                      | 10 | W | Mexico               | +6        |
| Miami         | 25                     | 45 | N | 80                      | 15 | W | Florida, USA         | +5        |
| Milwaukee     | 43                     | 02 | N | 87                      | 55 | W | Wisconsin, USA       | +6        |
| Minneapolis   | 45                     | 00 | N | 93                      | 15 | W | Minnesota, USA       | +6        |
| Montreal      | 45                     | 31 | N | 73                      | 34 | W | Quebec, Canada       | +5        |
| Moscow        | 55                     | 45 | N | 37                      | 42 | E | USSR, Europe         | -3        |
| Nairobi       | 1                      | 17 | S | 36                      | 50 | E | Kenya, Africa        | -3        |
| New Delhi     | 28                     | 37 | N | 77                      | 13 | E | India, Asia          | -5.5      |
| New Orleans   | 30                     | 00 | N | 96                      | 03 | W | Louisiana, USA       | +6        |
| New York      | 40                     | 43 | N | 74                      | 01 | W | New York, USA        | +5        |
| Oklahoma City | 35                     | 28 | N | 97                      | 32 | W | Oklahoma, USA        | +6        |
| Omaha         | 41                     | 15 | N | 96                      | 00 | W | Nebraska, USA        | +6        |
| Oslo          | 59                     | 56 | N | 10                      | 45 | E | Norway, Europe       | -1        |
| Paris         | 48                     | 52 | N | 2                       | 20 | E | France, Europe       | -1        |
| Perth         | 31                     | 58 | S | 115                     | 49 | E | West Australia       | -8        |
| Philadelphia  | 40                     | 00 | N | 75                      | 10 | W | Pennsylvania, USA    | +5        |
| Phoenix       | 33                     | 30 | N | 112                     | 03 | W | Arizona, USA         | +7        |
| Pittsburgh    | 40                     | 26 | N | 80                      | 00 | W | Pennsylvania, USA    | +5        |
| Prague        | 50                     | 06 | N | 14                      | 26 | E | Czechoslovakia, Eur. | -1        |
| Quebec        | 46                     | 50 | N | 71                      | 15 | W | Quebec, Canada       | +5        |



| Name           | Latitude<br>DeMin NS |    |   | Longitude<br>Deg Min EW |    |   | State,Country      | Time Zone |
|----------------|----------------------|----|---|-------------------------|----|---|--------------------|-----------|
| Rangoon        | 16                   | 46 | N | 96                      | 10 | E | Burma, Asia        | -6.5      |
| Reykjavik      | 64                   | 09 | N | 21                      | 58 | W | Iceland            | +1        |
| Rio de Janeiro | 22                   | 53 | S | 43                      | 17 | W | Brazil, S. America | +3        |
| Rome           | 41                   | 53 | N | 12                      | 30 | E | Italy, Europe      | -1        |
| Saigon         | 10                   | 46 | N | 106                     | 43 | E | Vietnam, Asia      | -7        |
| Salt Lake City | 40                   | 45 | N | 111                     | 55 | W | Utah, USA          | +7        |
| San Francisco  | 37                   | 45 | N | 122                     | 27 | W | California, USA    | +8        |
| San Juan       | 18                   | 29 | N | 66                      | 08 | W | Puerto Rico, USA   | +4        |
| Santiago       | 33                   | 30 | S | 70                      | 40 | W | Chile, S.America   | +4        |
| Seattle        | 47                   | 36 | N | 122                     | 20 | W | Washington, USA    | +5        |
| Seoul          | 37                   | 30 | N | 127                     | 00 | E | Korea, Asia        | -9        |
| Singapore      | 1                    | 17 | N | 105                     | 51 | E | Malacca, Asia      | -7.5      |
| Stockholm      | 59                   | 20 | N | 18                      | 05 | E | Sweden, Europe     | -1        |
| Sydney         | 33                   | 55 | S | 151                     | 10 | E | New S. Wales, Aus. | -10       |
| Taipei         | 25                   | 05 | N | 121                     | 32 | E | Taiwan, Asia       | -8        |
| Tananarive     | 18                   | 52 | S | 47                      | 30 | E | Madagascar         | -3        |
| Teheran        | 35                   | 40 | N | 51                      | 26 | E | Iran, Middle East  | -3.5      |
| Thule          | 77                   | 30 | N | 69                      | 29 | W | Greenland          | +4        |
| Timbuktu       | 16                   | 49 | N | 2                       | 59 | E | Mali, Africa       | 0         |
| Tokyo          | 35                   | 40 | N | 139                     | 45 | E | Japan, Asia        | -9        |
| Toronto        | 43                   | 39 | N | 79                      | 23 | W | Ontario, Canada    | +5        |
| Tripoli        | 32                   | 58 | N | 13                      | 12 | E | Libya, Africa      | -2        |



| Name           | Latitude<br>Deg Min NS |    |   | Longitude<br>Deg Min EW |    |   | State,Country        | Time Zone |
|----------------|------------------------|----|---|-------------------------|----|---|----------------------|-----------|
| Tunis          | 36                     | 50 | N | 10                      | 13 | E | Tunisia, Africa      | -1        |
| Vancouver      | 49                     | 13 | N | 123                     | 06 | W | Br. Columbia, Canada | +5        |
| Vienna         | 48                     | 13 | N | 16                      | 20 | E | Austria, Europe      | -1        |
| Vladivostok    | 43                     | 09 | N | 131                     | 53 | E | USSR, Asia           | -10       |
| Warsaw         | 52                     | 15 | N | 21                      | 00 | E | Poland, Europe       | -1        |
| Washington, DC | 38                     | 55 | N | 77                      | 00 | W | USA                  | +5        |
| Wellington     | 41                     | 17 | S | 174                     | 47 | E | New Zealand          | -12       |
| Winnipeg       | 49                     | 53 | N | 97                      | 10 | W | Manitoba, Canada     | +6        |
| Zanzibar       | 6                      | 10 | S | 39                      | 11 | E | Tanzania, Africa     | -3        |



## APPENDIX F

### SUPPLEMENTARY READING

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## PERIODICALS

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"Astronomy," Astro Media Corporation, Milwaukee, Wisconsin.

"Mercury," Astronomical Society of the Pacific, San Francisco, California.

"Observer's Handbook," Royal Astronomical Society of Canada, Toronto, Ontario.

"Scientific American," Scientific American, New York, New York.

"Sky and Telescope," Sky Publishing Corporation, Harvard College Observatory, Cambridge, Massachusetts.

## SOURCES

Astronomical Society of the Pacific, 1290 24th Ave., San Francisco, CA 94122

Willman-Bell, Inc., PO Box 35025, Richmond, VA 23235 (major supplier of astronomical books and charts).



## APPENDIX G BUYING A TELESCOPE

If DISTANT SUNS has done its job, by now you may be saying to yourself "Self, I wonder if I should get a small telescope?"

Well, what's stopping you?

When you first consider buying telescope, figure out what exactly you want to do. If you are merely interested in casual peeks at the planets, there is no need to get a \$6700 Compustar 11. Or if you want to something really portable for backpacking don't get a 17 inch Dobsonian when a good pair of binoculars might do the job.

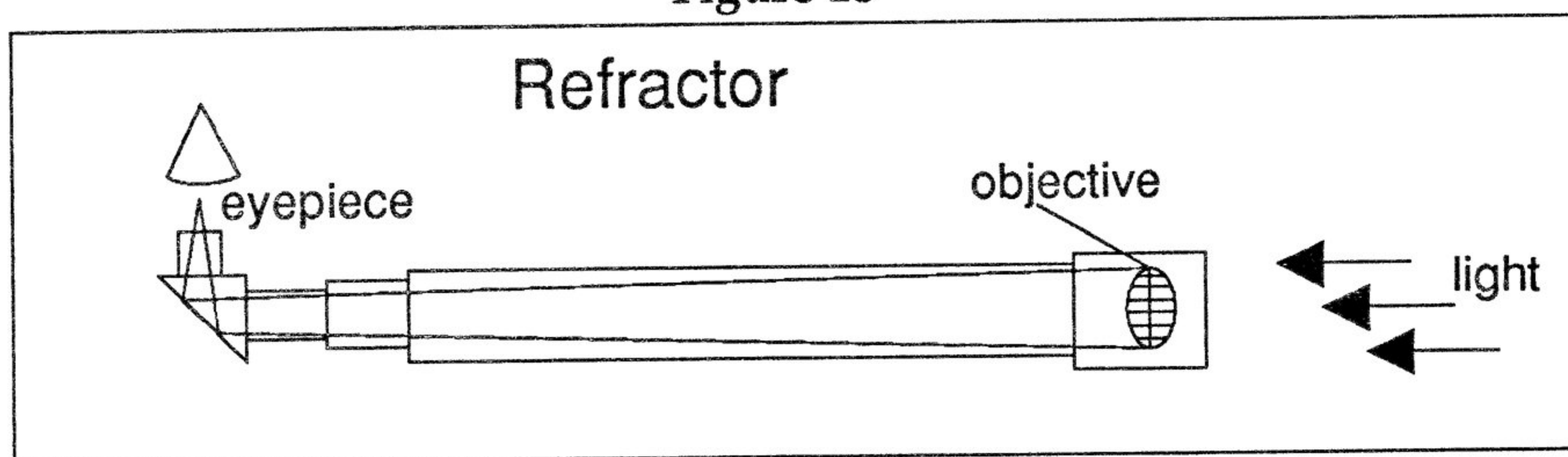
No doubt your first thought is "but I want to see everything!". Unfortunately, there are always going to be drawbacks to accept and choices to be made. Telescopes are measured in the size of their objective (either lenses or mirrors). So a "17 inch" Dobsonian will contain a mirror, 17" in diameter (in other words, big). Of course the larger the diameter, the more you will see, but the drawback is that a 17" is large and heavy. Such an instrument may quickly throw water on the enthusiasm of a novice observer if it takes 3 people to move it out to the backyard. On the other end is a "typical" beginner telescope, such as a 2.4 inch refractor or 6 inch reflector from your local Sears. While easy to transport, the deep-sky objects will not be nearly as spectacular, (although the planets and the moon most certainly will be). Other things to consider would be the accessories available. The more serious instruments are naturally going to have more goodies to spend your money on, while the simpler models might not.

As mentioned, the aperture is the chief method of measuring the general performance of a telescope. Scopes are simply "light buckets," so the larger the objective, the more light it can



capture and the sharper the image. Don't be misled by advertisements for instruments costing only \$200 but have 500 power. The "power" or enlarging capability of the telescope is likewise connected to the aperture size. The higher the power, the more spread out, or dimmer, the image will be. Also the less distinct it will be. A general rule of thumb is that the maximum usable power of a telescope is going to be 50 times its objective size in inches. Therefore a 2.4 inch refractor will be fine up to 120 power, after that you'd be fighting a losing battle. Theoretically the scope could be pushed to 500 power, but the image would be too dim and fuzzy to be usable. (By the way, 50 to 75 power is just right for most solar system observations, so magnification isn't everything).

Figure 18

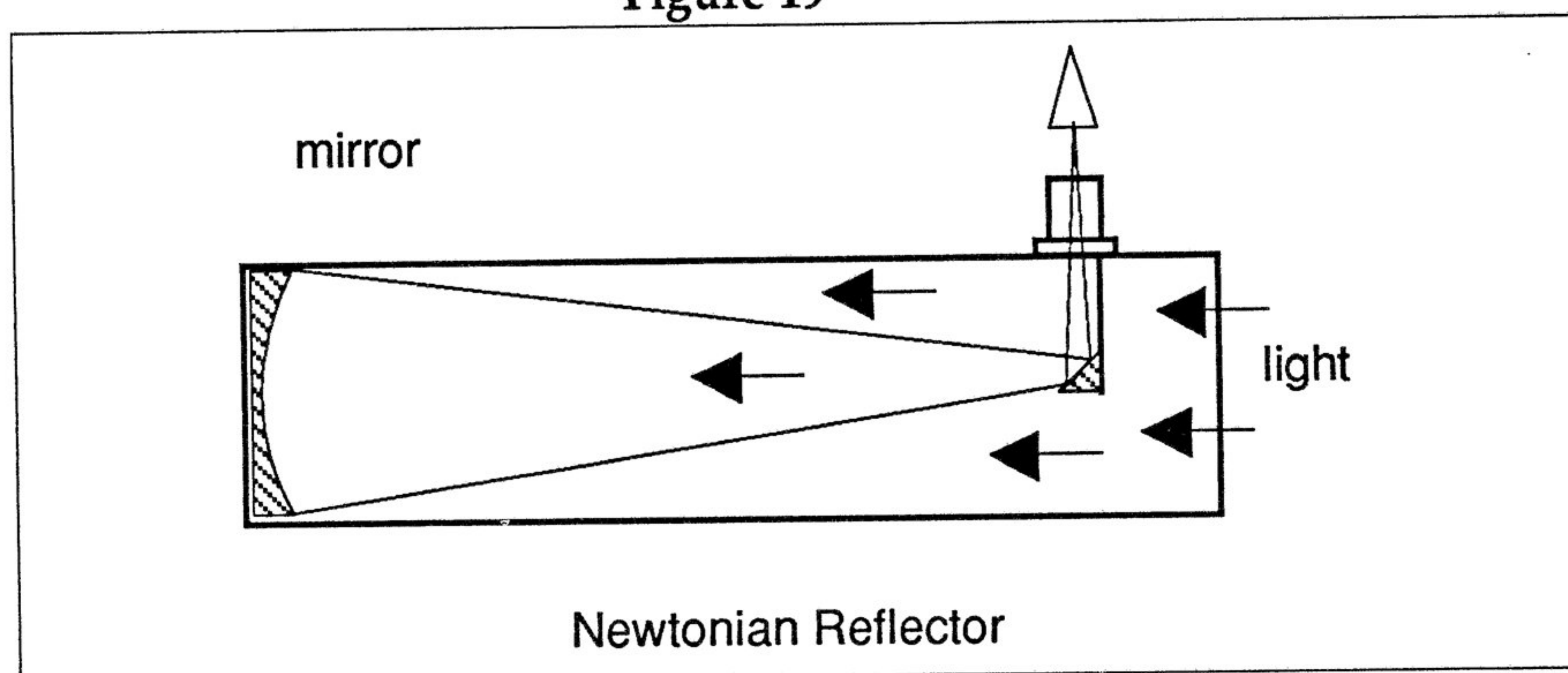


Perhaps the most familiar kind of scope is the good old "refractor," not much different than Galileo's original instrument. In its most simple form, a refractor combines a set of lenses at the front of a long tube, with an eyepiece at the other end (fig. 18). The standard scope of this type has a lens 60 millimeters in diameter (2.4 inches) and a tube about 3 feet long. Refractors are the most common small telescopes made, mass produced by several large volume vendors and usually sold in the toy sections of major stores. I would recommend staying away from these mass market instruments. While inexpensive, the optical quality is usually so poor as to make them nearly useless for anything but the largest and brightest objects. Quality



manufacturers such as Meade, Unitron and Pentax all make similar small refractors, but of much higher quality. These are perfect for casual viewing of the solar-system and some of the brighter deep-sky objects, but they just don't have the light gathering power to support astrophotography or serious deep-sky observations. Larger refractors are available, but once you get above 3" models, the prices become "astronomical" (sorry), not to mention the weight.

Figure 19



Besides the refractors there is the "reflector," which as its name would suggest, uses mirrors instead of lenses (fig. 19). The most common of these, the Newtonian, was developed by Sir Isaac himself. The light enters in through the front, reflects off of the primary mirror, into the secondary back at the front, and out of the eyepiece. A variation of this kind is the increasingly popular "Dobsonian-Newtonian," which sacrifices some general convenience for very low-cost instruments. Most telescopes are mounted on an "equatorial mount," which permits it to be tilted parallel to the earth's equator. This allows the scope to track the motion of the stars in only one movement around the central axis of the mount (the diurnal motion is very significant; even at low powers, the object can drift out of the



view in only a minute). The Dobsonian opts for the much simpler fork "alt-azimuth" mount which sits parallel to the ground. This means that tracking the objects would require two motions instead of one. Not much effort in and of itself, but it makes automatic motor drives required for astrophotography next to impossible. If you don't think you'll try photography, a Dobsonian might just be the scope for you. The no frills Odyssey-8 and 10 inch scopes by Coulter Optical have been highly regarded, and cost less than 300 bucks. Fancier Newtonian scopes by Meade or Celestron in the same sizes are nearly 3 times as much.

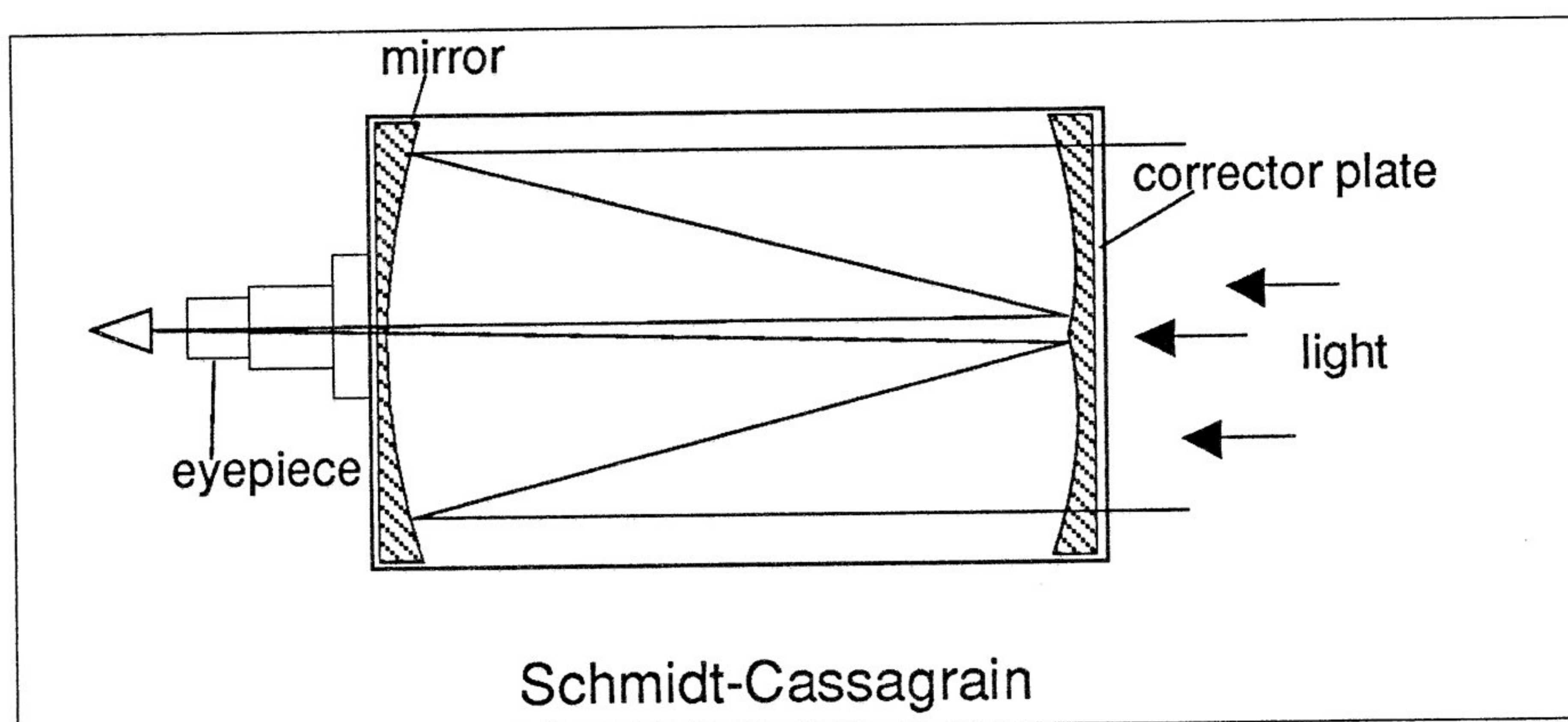


Figure 20

The most popular serious telescopes made today are the Catadioptrics, and are respected for their utter compactness. Known as a "Schmidt-Cassegrain" (SCT), an 8 inch instrument might be only 16 inches long, 1/3 the length of a standard Newtonian of the same diameter. The key is the folded optics as shown in fig. 20. The light enters in through a corrector lens, reflects off of the primary to a secondary on the plate and back through a hole in the primary. This places the eyepiece in the back of the scope making for easy viewing. SCTs come with a wide variety of lenses, camera mounts, tracking devices and



computer controls. The "typical" SCT is an 8" model, and will go for around \$1000 to \$1300, although sizes range from 3 1/2" on up to 14". The most common are the Celestron, Meade and Bushnell.

While you're looking at all of these high-powered instruments, don't overlook the "richest-field" telescopes. These are deliberately lower power devices meant to give wider sweeping views of the sky. Normal scopes will be much too powerful to view the star clouds of Sagittarius or the larger details of the Hyadies cluster (something like investigating the Mona Lisa with an electron microscope). Richest field telescopes are very compact (the Edmund Astroscan slips over the shoulder) and generally quite inexpensive. Along the same line of thought would be a good pair of binoculars. While they don't come close to the light gathering power of an Astroscan, they can provide hours of enjoyment as you sweep across the sky lying on your back munching popcorn.

You may want to think about getting a used telescope. If it is a name brand, it has already depreciated about as much as it will and so could easily be sold once you outgrow it or lose interest in the hobby. Prices will likely be 15% to 20% off new instruments.

Before buying I would suggest visiting your local astronomy club. You should probably be able to find out how to get in touch with them through your local college observatory or astronomy department. Astronomy clubs periodically have "star parties" in which the members and any interested visitors spend all night observing at some remote site. From here you should be able to get hands-on experience with every conceivable type and brand of scope, as well as getting names of those who might have one for sale.

Other than clubs, "Sky and Telescope" or "Astronomy" magazine will provide excellent information. "Astronomy" generally runs telescope buyer's guides in the October issues which



should be available at your local library, or from Astro-Media (address in reference list).

If you are adventurous, you may want to try to make your own telescope. The astronomy department of your local community college may offer telescope making classes during the summer. The typical homemade instrument is either a 6 or 8 inch reflector, and can offer a real sense of accomplishment that buying a scope never can.



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## ADDENDUM

Instructions for using P/I from a floppy based system.

Place a copy of Standard Amiga Workbench (unprotected) in drive DF0:

Place Distant Suns disk in DF1:

Double click on Distant Suns disk icon.

Double click on Font-Mover icon.

This will bring up a small window showing what it is doing. When this window goes away, you can double click on the Distant Suns icon and start the program. The P/I function will use whatever printer driver you have selected on your workbench. (Generic will do, since Distant Suns outputs on standard ASCII text.)

The distribution disk (the disk which comes in the Distant Suns box), does not have enough space to include printer support. If your system has only 512K, your normal workbench start-up sequence will use up memory needed to run the program. Therefore, Distant Suns must be self-booted on 512K systems, in which case it will not permit the use of the P/I feature for the reasons given above.



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